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GEORGE C. EDWARDS, *Chairman*

C. E. GRUNSKY

BARTON WARREN EVERMANN, *Editor*

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JUNE 11, 1923

PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

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BY

JOHN VAN DENBURGH

Curator, Department of Herpetology

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George C. Edwards, *Chairman*

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PROCEEDINGS

Fourth Series

VOLUME I

Expedition of the California Academy of Sciences to the Galapagos Islands, 1905-1906.

VOLUME II, Part I

Expedition of the California Academy of Sciences to the Galapagos Islands, 1905-1906.

VOLUME II, Part II

PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

FOURTH SERIES

VOL. X, No. 1, pp. 1-27, pls. 1-2 AUGUST 6, 1920

I

A FURTHER STUDY OF VARIATION IN THE GOPHER-SNAKES OF WESTERN NORTH AMERICA

BY

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Curator, Department of Herpetology

In August of last year the writer and Joseph R. Slevin published the results of a study of some three hundred specimens of *Pituophis* from western North America[1]. Probably no one who has not undertaken such a study can realize the amount of time and effort necessary for gathering, analyzing, digesting, and formulating the data derived from such a mass of material as was involved in our earlier study of the garter-snakes of the genus *Thamnophis*. The time and effort expended were so great that in the subsequent study of *Pituophis* the attempt was made to reach conclusions without so much attention to detail. The result was that, while the conclusions reached were valuable and probably correct, as far as they went, they never have been satisfactory as a solution of the problems in variation and distribution offered by this genus. Further study of the data published in that paper indicated the probability that the snakes

[1] The Gopher-Snakes of Western North America. <Proc. Cal. Acad. Sci., 4th Ser., vol. 9, no. 6, pp. 197-220, pls. 11-13, August 21, 1919.

we had regarded as one subspecies, and called *Pituophis catenifer annectens,* were not all alike, but represented several centers of geographic variation. It has seemed important to determine whether this actually is so, and whether conclusions more satisfactory than those published could be attained by further study of the group.

Such study required additional data. The color patterns of these snakes had not been considered in our former investigation for the reason that published records seemed to show so much variation as to render them valueless as a means of classification. Investigation of them now, however, shows that they do afford valuable data. Individual variation is great, but so are the average differences found in several geographic areas. The whole subject has been reopened, and the results of additional study are given in the present paper.

Reverting to the former paper, it may be recalled that it was there shown that the gopher-snakes of western North America may be divided into two groups by the number of their gastrosteges. This is indicated in the following diagram, figure 1, in which the upper curve represents the gastrostege counts in the snakes we called *Pituophis catenifer catenifer,* while the lower curve shows the same data concerning those regarded as *Pituophis catenifer annectens:*

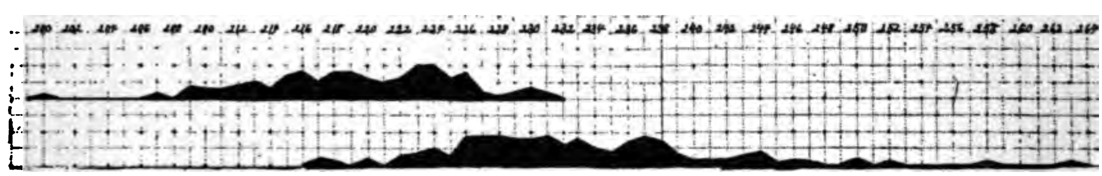


Fig. 1

As one proceeds south and east from the cool north coast regions toward the warm south coast and interior desert regions, the average counts gradually increase. Although the transition is gradual, these gastrostege counts are of great use in the separation of these snakes into the two groups which we then regarded as two subspecies.

This same difference and relationship are shown when the combined gastrostege and urostege counts are charted for the two groups, as has been done in figure 2. In this chart the

and the northern portions of the San Joaquin. The difference between these two curves points to the necessity of recognizing two subspecies here, a coast race, *P. catenifer catenifer,* and an interior race, *P. catenifer heermanni.*

The third, fourth, fifth, and sixth curves charted in this figure 3 represent respectively snakes (3) from the San Diegan Fauna, (4) from the desert regions of California, the southern San Joaquin Valley and Nevada, (5) from Utah, and (6)

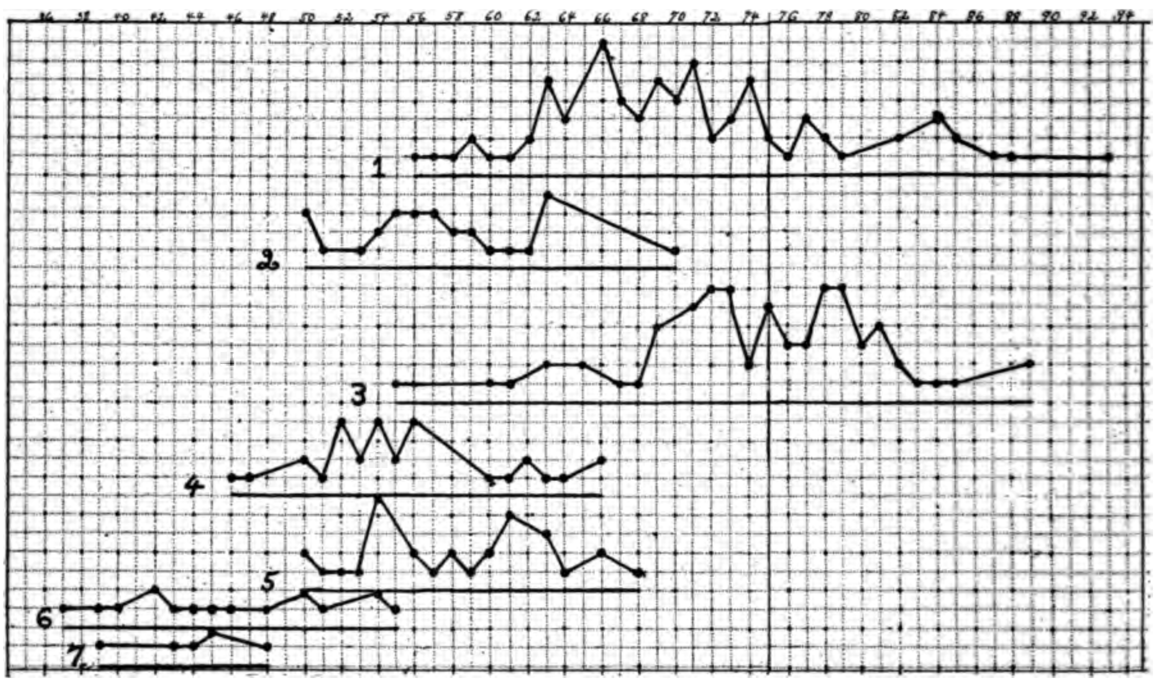
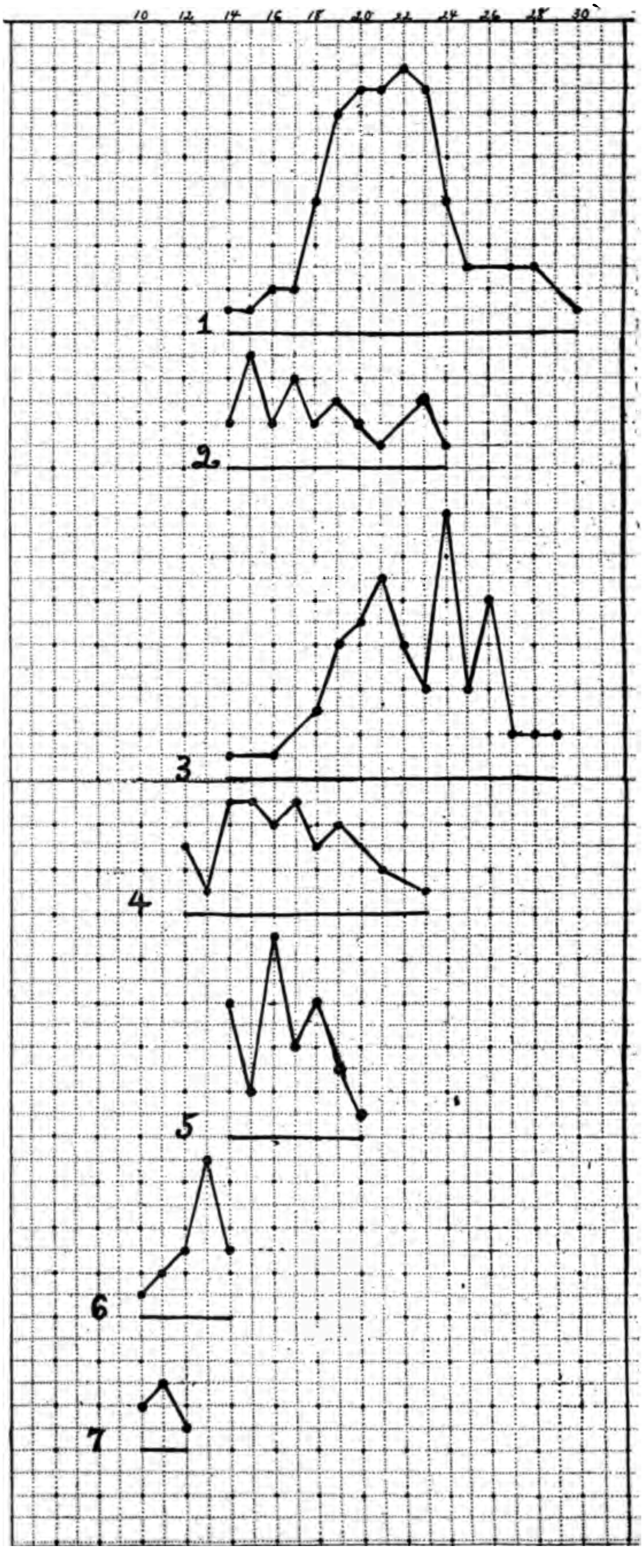


Fig. 3

from Arizona. Curve 3 shows that the snakes from the coast of southern California have more blotches than those of any of the other regions where the gastrosteges are numerous. In this respect these snakes are like those from the northern coast, *P. catenifer catenifer,* from which, however, they differ in other respects. The difference between these snakes and those represented by the other curves necessitates recognition as a distinct subspecies, *P. catenifer annectens,* using this name in a restricted sense.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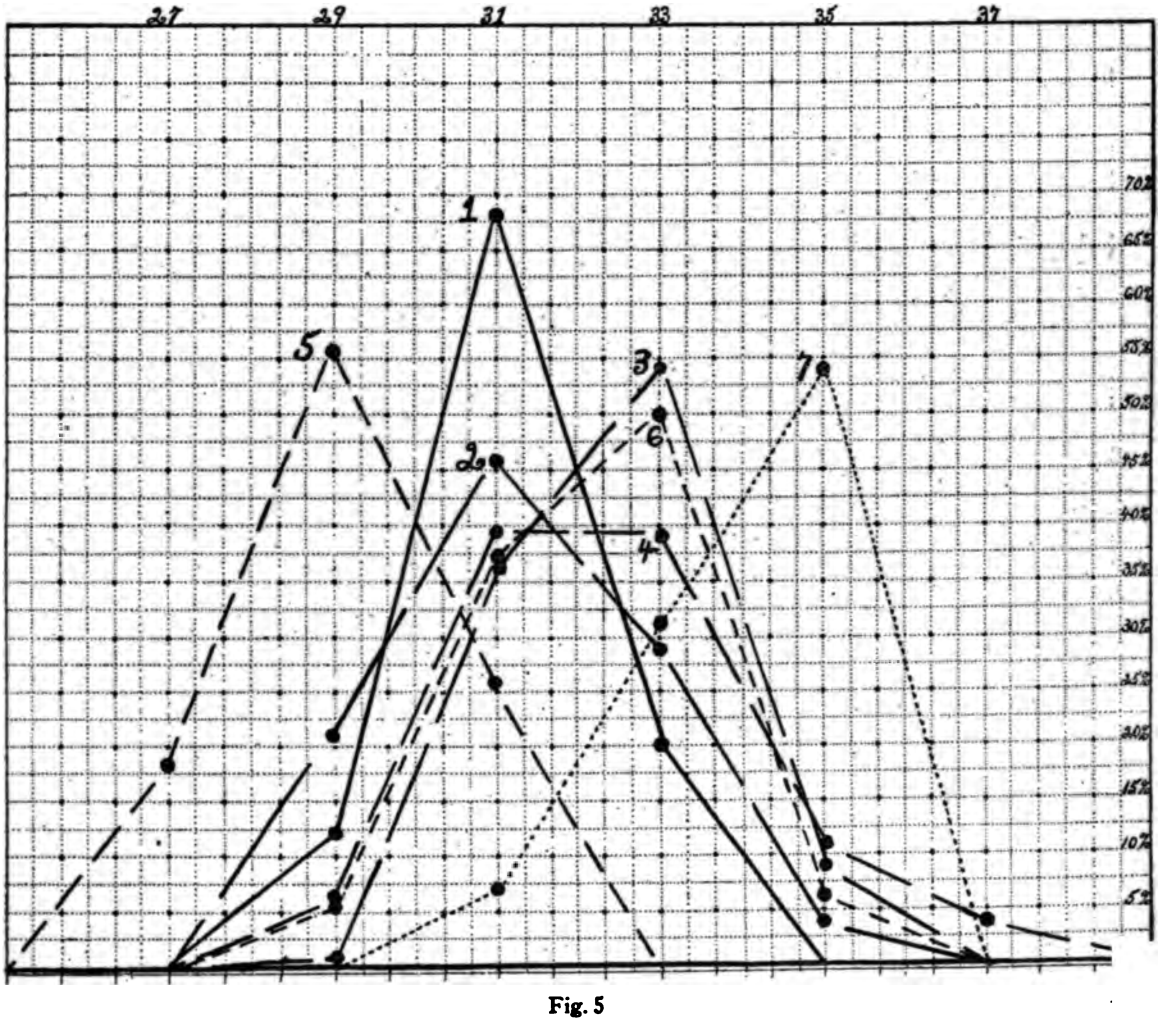

Fig. 5

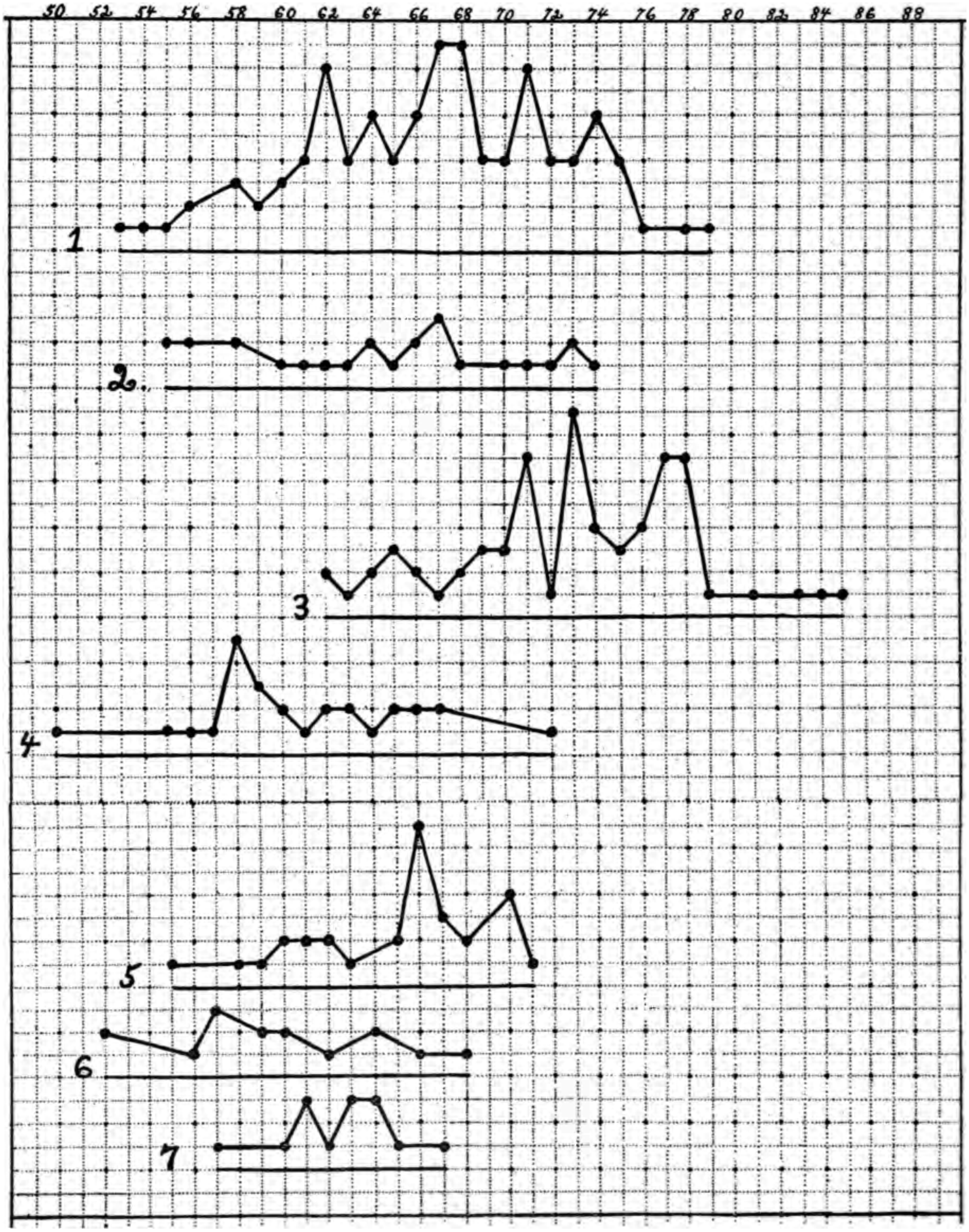

Fig. 6

Where individual variation is so great in races which integrade and are so closely related, it probably is impossible to make a "key" which will properly refer all specimens. However, it is believed that the following synopsis will serve this purpose for most individual specimens, and perhaps for all series of specimens from one locality.

SYNOPSIS OF SPECIES AND SUBSPECIES

a. Coloration on anterior half of body not largely red.

b. The number of gastrosteges less the number of dorsal blotches on body and tail rarely exceeds 151.

c. Gastrosteges fewer (200 to 230), average fewer than 225; urosteges fewer (51 to 80), average in males 70, females 63; scale-rows usually (70 to 75%) not more than 31.

d. Dorsal blotches more numerous on body (56 to 93, average 70) and tail (14 to 30, average 21.4).

P. c. catenifer.—*p. 13*

dd. Dorsal blotches fewer on body (48 to 70, average 57.6) and tail (13 to 19, average 15).

P. c. heermanni.—*p. 16*

cc. Gastrosteges more numerous (217 to 243), average more than 225; urosteges more numerous (62 to 85), average in males 76, females 70; scale-rows usually (63%) more than 31.
Dorsal blotches numerous on body (54 to 89, average 74) and tail (14 to 29, average 22.8).

P. c. annectens.—*p. 17*

bb. The number of gastrosteges less the number of dorsal blotches on body and tail usually exceeds 151; gastrosteges more than 220.

e. The sum of the number of scale-rows and of preoculars on both sides of head rarely exceeds 33; usually one preocular.

P. c. stejnegeri.—*p. 21*

ee. The sum of the number of scale-rows and of preoculars on both sides of head usually exceeds 33.

f. The sum of the number of caudal blotches and preoculars of both sides of head usually exceeds 16; usually two preoculars; posterior dorsal blotches not distinctly reddish.

P. c. deserticola.—*p. 19*

ff. The sum of the number of caudal blotches and preoculars of both sides of head rarely exceeds 16; usually one preocular; posterior dorsal blotches often distinctly reddish or red-brown.

P. c. rutilus.—*p. 24*

aa. Coloration on anterior half of body largely red. Gastrosteges 233 to 257; scales usually in 35 or 33 rows; dorsal blotches few (average 44 on body, 11 on tail); supralabials usually nine or more.

P. vertebralis.—*p. 27*

River, source of the Salinas River), and Santa Barbara (Santa Cruz Island) counties.

Variation.—One specimen has no loreal plates; the other one hundred and three all have the normal 1–1. The preoculars are 2–2 in seventy-nine, or 78%; 1–1 in seventeen, or 16%; and 1–2 in six, or 6%. The postoculars are 3–3 in seventy-one, or 69%; 3–4 in eighteen, or 17%; 4–4 in eleven, or 11%; 4–5 in one, or 1%; 2–3 in one, or 1%; and 2–2 in one, or 1%. The temporals are 4–4 in thirty-nine, or 38%; 3–3 in twenty-six, or 25%; 3–4 in twenty-one, or 20%; 4–5 in nine, or 9%; 2–3 in three, or 3%; 2–2 in three, or 3%; 5–5 in one, or 1%; and 2–4 in one, or 1%. The supralabials are 8–8 in fifty-six, or 54%; 8–9 in twenty-seven, or 26%; 9–9 in fourteen, or 14%; 9–10 in three, or 3%; 7–8 in two, or 2%; 10–10 in one, or 1%. The infralabials are 13–13 in thirty-two, or 31%; 12–12 in twenty-two, or 21%; 12–13 in nineteen, or 18%; 11–12 in nine, or 9%; 13–14 in seven, or 7%; 11–11 in six, or 6%; 11–13 in three, or 3%; 10–10 in three, or 3%; 14–14 in one, or 1%; and 10–11 in one, or 1%. The scale-rows are 31 in sixty-nine, or 68%; 33 in twenty, or 20%; and 29 in twelve, or 12%; the average is 31.1 rows. The gastrosteges vary in number from 200 to 230, males having from 207 to 230, females from 200 to 230; the average in fifty-four males is 217, in forty-six females is 220. The urosteges vary from 53 to 79; males having from 59 to 79, females from 53 to 78; the average in fifty-three males is 69, in forty-five females, 64.

The dark blotches between head and anus in seventy-five specimens vary from 56 to 93, the average being 70. On the tail, in eighty-three specimens, they vary from 14 to 30, and average 21.4.

The counts of blotches in the various specimens are shown below.

Pituophis catenifer heermanni (Hallowell)

Valley Gopher-Snake

(Plate 1, fig. 1)

Diagnosis.—Gastrosteges average fewer than 225; urosteges average 60 to 68; scale-rows most frequently 31; preoculars usually two; supralabials most frequently eight; dorsal blotches fewer, average on body 58, on tail 15; no red in coloration.

Type locality.—Cosumnes River, California.

Distribution.—The Klamath region, Oregon, and in California, Modoc County, the Sacramento Valley, the northern part of the San Joaquin Valley, and the western slope of the Sierra Nevada. In Oregon it has been taken near Klamath Falls, Klamath County. Californian specimens have been collected in Modoc (Canby, Goose Lake Meadows, Sugar Hill, between Alturas and Davis Creek, Dry Creek in the Warner Mts.), probably Shasta (McCloud River), Tehama (Tehama), Glenn (Fruto, Winslow), Butte (between Live Oak and Gridley), Yolo (Grand Island Landing), Placer (Lander near Colfax), El Dorado (Fyffe, Riverton), San Joaquin (Tracy), Merced (Los Baños, Snelling), Mariposa (between Kinsley and Maculey's Stage Station, Coulterville, Pleasant Valley), Madera (vic. Madera), and Fresno (King's River, Dunlaps, Clovis) counties.

Variation.—The loreal is 1–1 in all of the twenty-eight specimens. The preoculars are 2–2 in twenty-six, or 93%; and 1–1 in two, or 7%. The postoculars are 3–3 in twenty-three, or 85%; 4–4 in three, or 11%; and 4–5 in one, or 4%. The temporals are 4–4 in eleven, or 45%; 3–4 in five, or 21%; 5–5 in three, or 13%; 3–3 in three, or 13%; 4–6 in one, or 4%; and 2–3 in one, or 4%. The supralabials are 8–8 in twelve, or 48%; 8–9 in eight, or 32%; and 7–7, 7–8, 9–9, 9–10, and 10–10, each in one, or 4%. The infralabials are 13–13 in twelve, or 50%; 12–12 in six, or 25%; 14–14 in two, or 8%; 12–13 in two, or 8%; and 12–14 and 11–14 each in one, or 4%. The scale rows are 31 in thirteen, or 46%; 33 in eight, or 29%; 29 in six, or 21%; and 35 in one, or 4%; the average is 31.3 rows. The gastrosteges vary in number from 209 to 231, males having from 209 to 231, females from 218 to 231; the average in six-

teen males is 219, in twelve females, 224. The urosteges vary from 55 to 74, males having from 61 to 74, females from 55 to 66; the average in fifteen males is 68, in eleven females is 60.

The dark blotches between head and anus in twenty-eight specimens vary from 48 to 70, the average being 57.6. On the tail, in thirty-two specimens, they vary from 13 to 19, and average 15. The counts of the blotches are shown below.

Number	Blotches on		Locality	Number	Blotches on		Locality
	Body	Tail			Body	Tail	
C 4012	70	23	2	C 3608	54	14	27
S 5631	61	19	9	C 5595	59	15	28
S 5633	59	23	9	C 2080	63	24	29
39637	62	19	10	C 2081	60	17	30
27333	63	19	11	C 2082	56	19	31
C 6264	..	..	12	C 2083	56	20	32
C 4016	55	16	13	S 6500	..	..	40
C 4015	57	14	14	43521	48	15	43
C 4014	63	21	14	43522	56	15	43
41670	50	16	18	C 2759	57		43
C 5883	54		24	C 4013	63	20	67
C 5884	55	17	24	C 4011	58	19	69
C 5885	53	14	25	20413	65	16	72
C 5886	51	17	26	44161	58	18	74
41699	50	15	27	44241	57	18	75

Pituophis catenifer annectens (Baird & Girard)

San Diegan Gopher-Snake

(Plate 1, fig. 2)

Diagnosis.—Gastrosteges average more than 225; urosteges numerous, average 70 to 76; scale-rows most frequently 33; preoculars usually two; supralabials most frequently eight; dorsal blotches many, average on body 74, on tail 22.8; no red in coloration.

Type locality.—San Diego, California.

Distribution.—This subspecies occupies the coast region of southern California and northern Lower California, and has been found on some of the islands off the coast. We have examined specimens from Santa Barbara (Santa Barbara), Ventura (Pine Creek), Los Angeles (Charter Oak, Cold Water Canyon, La Crescenta, Pasadena, Mt. Wilson, Sierra Madre),

San Bernardino (Ontario), Riverside (Colton, San Bernardino Mts., Riverside, San Jacinto, San Jacinto Mts.), and San Diego (Warner Pass, Agua Caliente, Cahuilla Valley, Julian, Cuyamaca Mts., Campo), counties, California, and from Ensenada, San Martin Island, and South Coronado Island, Lower California.

It is probably this subspecies of gopher-snake which has been observed, but not captured, on Santa Catalina Island. Those of Santa Cruz Island, however, are ***Pituophis catenifer catenifer***.

Variation.—Sixty-nine specimens all have loreals 1–1. The preoculars are 2–2 in forty-four, or 64%; 1–1 in twenty, or 29%; and 1–2 in five, or 7%. The postoculars are 3–3 in forty, or 59%; 4–4 in thirteen, or 19%; 3–4 in eleven, or 16%; and 2-3, 2–4, 4–5, and 5–5, each in one. The temporals are 4–4 in twenty-three, or 34%; 3–3 in fifteen, or 22%; 3–4 in twelve, or 18%; 4–5 in five, or 7%; 5–5 in five, or 7%; 3–5 in two, or 3%; and 2–2, 2–3, 2–4, 4–6, and 5–6, each in one. The supralabials are 8–8 in thirty-three, or 48%; 9–9 in nineteen, or 27%; and 8–9 in seventeen, or 25%. The infralabials are 13–13 in thirty-four, or 49%; 13–14 in ten, or 14%; 12–12 in eight, or 12%; 12–13 in seven, or 10%; 14–14 in three, or 4%; 11–13 in two, or 3%; and 10–11, 11–11, 11–12, 12–14, and 14–15, each in one. The scale-rows are 33 in thirty-seven, or 54%; 31 in twenty-five, or 36%; 35 in six, or 9%; and 29 in one, or 1%; the average is 32.4 rows. The gastrosteges vary in number from 217 to 243, males having from 217 to243, females from 218 to 240; the average in forty-three males is 228, in twenty-five females, 231. The urosteges vary from 62 to 85, males having from 62 to 85, females from 62 to 83; the average in thirty-nine males is 76, in twenty-four females, 70.

The dark blotches between head and anus in seventy-one specimens vary from 54 to 89, the average being 74. On the tail in sixty-five specimens they vary from 14 to 29, and average 22.8. The counts of the blotches are shown in full below.

County, the valleys east of the Sierra Nevada in California, and probably nearly all of Nevada; possibly Idaho and eastern Washington.

From Nevada, I have examined specimens of this subspecies from Humboldt (Thousand Creek Flat, Virgin Valley, Big Creek Pine Forest Mountains), Washoe (Pyramid Lake, Nixon), Ormsby (Carson), Lander (Austin), Elko (Carlin) and Esmeralda (Palmetto Mountains), counties.

Californian specimens examined have been collected in Imperial (Silsbee), Riverside (Mecca), San Bernardino (Victorville, Hesperia), Mono (Benton), Kern (Walker Pass, Tehachapi Mountains, Isabella, Delano, Bakersfield, Buttonwillow), and San Luis Obispo (Simmler, Pozo, Palo Prieto, Shandon) counties.

Variation.—Twenty-eight specimens from California and western Nevada show the following variations: The loreals are 1–1 in all. The preoculars are 2–2 in twenty-four, or 86%; 1–2 in two, or 7%; and 1–1 in two, or 7%. The postoculars are 3–3 in twenty-two, or 79%; 4–4 in five, or 18%; and 3–4 in one, or 3%. The temporals are 3–4 in eleven, or 39%; 4–4 in five, or 18%; 4–5 in four, or 14%; 5–5 in three, or 11%; and 2–3, 3–3, 3–5, 5–6, and 6–6, each in one, or 3%. The supralabials are 8–8 in seventeen, or 61%; 8–9 in six, or 21%; 9–9 in four, or 14%; and 8–10 in one, or 4%. The infralabials are 13–13 in thirteen, or 46%; 12–12 in six, or 21%; 12–13 in four, or 14%; 12–14 in two, or 7%; 13–14 in two, or 7%; and 14–14 in one, or 4%. The scale-rows are 33 in eleven, or 39%; 31 in eleven, or 39%; 35 in three, or 11%; 29 in two, or 7%; and 37 in one, or 4%; the average is 32.3 rows. The gastrosteges vary in number from 223 to 263, males having from 224 to 252, females from 223 to 263; the average in twelve males is 234, in sixteen females, 239. The urosteges vary from 50 to 72, males having from 58 to 72, females from 50 to 67; the average in twelve males is 64, in fifteen females, 59.

The dark blotches between head and anus in twenty-eight specimens vary from 46 to 66, the average being 55. On the tail they vary from 12 to 21, and average 15.4. The counts of these blotches are shown in full below.

labials usually eight, often nine. Infralabials usually 13, often 12, sometimes 11 or 14. Temporals of first row varying from two to five, usually four. Genials in two pairs, anterior larger. Scales on body in 27 to 33 rows, usually 29, keeled except in a varying number of rows on each side. Anal plate not divided. Gastrosteges varying in number from 223 to 241, males having from 227 to 241, females from 223 to 240. Urosteges in two series of from 55 to 71, males having from 58 to 71, females from 55 to 62.

The ground color is pale brownish or grayish-yellow, sometimes more or less obscured by the spreading of the blotches or the presence of black or dark brown marks along the keels of its scales. Along the middle of the back, from the head to a point over the anus, is a series of from 50 to 68 (average 58) dark blotches. These blotches are brown on the central part of the body but are black anteriorly and posteriorly. On the upper surface of the tail are from fourteen to twenty (average 16.5) blackish blotches. On the anterior portion of the body the blotches are more or less rounded, but posteriorly they tend to become quadrate. There are several series of alternating, often more or less confluent, dark blotches or spots on the sides. Across the top of the head, between the preocular plates, is a moderately narrow brown band, very definite and well-defined. There are similar bands or spots below the center of the eye and running back and down from the upper postocular plate. The top of the head posteriorly has a few, small, scattered, dark spots. The spaces between the dark dorsal blotches on the posterior portion of the body are yellow or orange-yellow, usually somewhat obscured by dark brown streaks along the keels of the scales. The lower surfaces are yellow or yellowish-white with irregular spots or blotches of dark brown or black on the gastrosteges and urosteges. There is no definite median subcaudal black band.

Length to anus..	758	800	863	1028	1125	1125
Length of tail...	126	148	168	179	190	207

Variation.—Twenty-nine specimens from Utah show the following variations: The loreals are 1–1 in all. The preoculars are 1–1 in twenty-one, or 87%; and 2–2 in three, or 13%

Walla Walla County, Washington, may belong here rather than with *P. catenifer deserticola,* but their final disposition must await additional material. They have twenty-nine and thirty-one scale-rows and one or two preoculars (50% each), and gastrosteges from 231 to 244.

Pituophis catenifer rutilus, new subspecies

Arizona Gopher-Snake

(Plate 2, fig. 2)

Diagnosis.—Gastrosteges numerous, average more than 225; urosteges average 57 to 63; scale-rows most frequently 33; preocular normally single; supralabials usually eight; dorsal blotches very few, average on body 46, on tail 12.5; coloration often somewhat reddish posteriorly.

Type.—Cal. Acad. Sci. No. 33869, adult female, collected by J. R. Slevin at Tucson, Pima Co., Arizona, April 11, 1912.

Description.—Head somewhat flat-topped, with snout projecting and rather narrow. Temporal regions not swollen. Rostral plate very large, prominent, not very narrow, often recurved between internasals on top of snout; bounded behind by internasal, anterior nasal, and first labial plates. Plates on top of head are a pair of internasals, a variable number of prefrontals (normally four), a frontal, supraocular of each side, and a pair of parietals. Anterior and posterior nasals usually distinct. Loreal usually elongate. Preocular usually one, occasionally two. Postoculars usually three, often four, sometimes five. Supralabials usually eight, often nine, rarely 10. Infralabials usually 12, often 13, sometimes 11 or 14. Temporals of first row varying from two to five, usually four. Genials in two pairs, anterior larger. Scales on body in 29 to 35 rows, usually 33, keeled except in a varying number of rows on each side. Anal plate not divided. Gastrosteges varying in number from 222 to 258, males having from 222 to 237, females from 227 to 258. Urosteges in two series of from 52 to 68, males having from 57 to 68, females from 52 to 60.

The ground color is pale yellow or grayish-yellow, sometimes more or less obscured by the spreading of the blotches

222 to 258, males having from 222 to 237, females from 227 to 258; the average in six males is 227, in nine females, 237. The urosteges vary from 52 to 68, males having from 57 to 68, females from 52 to 60; the average in six males is 63.5, in nine females, 57.

The dark blotches between head and anus in 16 specimens vary from 37 to 55, the average being 46. On the tail they vary from 10 to 14, and average 12.5. The counts of these blotches are given in full below.

Number	Blotches on		Locality	Number	Blotches on		Locality
	Body	Tail			Body	Tail	
34755	39	10	4	33869	48	13	8
17541	50	12	5	33870	44	13	8
17546	40	11	5	33447	54	13	9
17547	45	13	5	C	43	12	..
C 1824	54	14	6	C	50	14	..
S 1131	55	13	7	C	37		..
S 1705	42	13	7	C	51	13	..
S 1714	42	11	7	C	46	14	..

Distribution.—I have examined specimens of the Arizona Gopher-Snake taken at Yuma, Yuma County, the Colorado River above Bill Williams River, Mohave County, Cave Creek, Maricopa County, Fort Lowell and the Santa Cruz River near Tucson, Pima County, and the Huachuca Mountains, Cochise County, Arizona. Specimens of *Pituophis* from Arizona have been recorded as collected at Oak Orchard, Camp Grant, Wilton Springs, Tucson, Gila River, White River Canyon, Fort Whipple, Grand Canyon, and at Las Gijas in Pima County.

Remarks.—The specimens from Mohave and Yuma counties, and a specimen from Silsbee, Imperial County, California (referred to *P. c. deserticola*) show more or less intergradation between the Arizona and the Desert Gopher-Snakes. These specimens have very many gastrosteges, while those from extreme southeastern Arizona have fewer. Indeed, some of the latter have so few as to indicate intergradation with the gopher-snakes of New Mexico which Ruthven has referred to *P. c. sayi*, but which may possibly require recognition as a distinct subspecies, *P. sayi affinis* (Hallowell).

Figure 1.—*Pituophis catenifer heermanni* (Hallowell). Valley Gopher-Snake. Photograph from a living specimen collected five miles south from Madera, Madera County, California, May 10, 1920.

Figure 2.—*Pituophis catenifer annectens* (Baird & Girard). San Diegan Gopher-Snake. Photograph from a living specimen collected near Campo, San Diego County, California, about May 12, 1920.

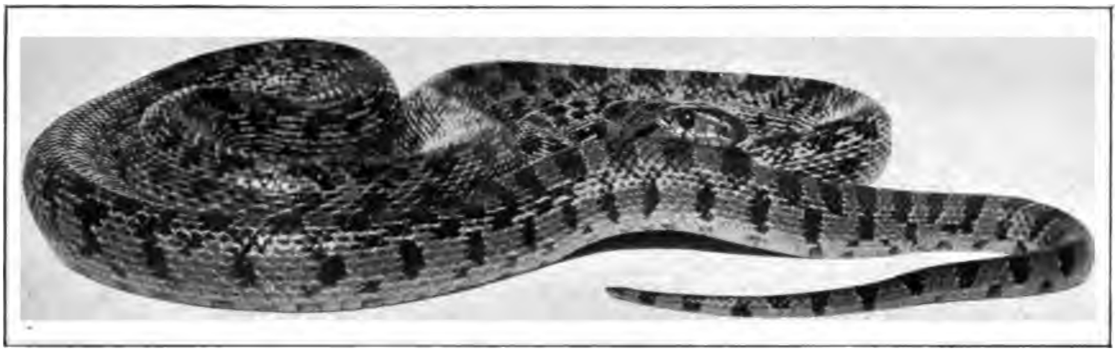

Figure 1.—*Pituophis catenifer stejnegeri* Van Denburgh. Utah Gopher-Snake. Photograph of a living adult male from Provo Canyon, Wasatch Mountains, Wasatch County, Utah.

Figure 2.—*Pituophis catenifer rutilus* Van Denburgh. Arizona Gopher-Snake. Photograph of a living adult from Huachuca Mountains, Cochise County, Arizona.

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II

DESCRIPTION OF A NEW SPECIES OF RATTLESNAKE (CROTALUS LUCASENSIS) FROM LOWER CALIFORNIA

BY

JOHN VAN DENBURGH

Curator, Department of Herpetology

The first specimens of the diamond rattlesnake of the Cape Region of Lower California were sent from Cape San Lucas by John Xantus. Cope recorded them, in 1861, as *Caudisona atrox sonoraensis,* but remarked that they were more delicately tinted than Sonoran specimens, the dorsal rhombs being more perfect and their yellow borders brighter. A considerable number of specimens have been collected in southern Lower California in more recent years, and have been recorded usually as *C. atrox*. The differences in coloration, however, seem to be of such constancy as to make it desirable to regard the San Lucan snakes as a species distinct from both *C. atrox* and the reddish *C. exsul*. I, therefore, propose for this snake the name

Crotalus lucasensis, new species

(Plate 3, fig. 1)

Diagnosis.—Similar to *C. atrox* (Plate 3, fig. 2) but coloration brighter, much less punctulate, and with dorsal rhombs more completely enclosed in light borders.

Type.—Cal. Acad. Sci. No. 45888, collected by Joseph R. Slevin at Agua Caliente, Cape Region of Lower California, July 26, 1919.

Distribution.—The southern portion of Lower California, Mexico.

Description of type.—Large. Head broad, flat-topped; rostral higher than wide, in contact with anterior nasal. Two nasals; two preoculars; three postoculars; two loreals. Supraocular large, not raised into a horn-like process, separated from its fellow by about six or seven irregular rows of scales. Sixteen and seventeen superior and nineteen inferior labials, the first pair of the latter divided horizontally as in *C. exsul.* A single pair of genials. About five rows of scales between supralabials and eye. Scales in twenty-seven rows, keeled except in one or two rows on each side. Gastrosteges 186; urosteges 26.

The general color is yellowish-brown, or brownish-yellow, with a series of large, darker brown blotches along the back. These blotches are well defined, are usually enclosed in continuous light borders laterally as well as dorsally, and show little of the punctulate or pepper-and-salt style of coloration so characteristic of *C. atrox.* The sides are clouded or blotched with brown, more or less indefinitely outlined with light yellow or white. The head is somewhat mottled above. A yellow or white stripe runs across the side of the face from the preocular plates to the mouth. The scales behind and above this light stripe are darker than the ground color and are set off posteriorly by a light streak which runs down and back from the corner of the mouth. The tail is grayish with about four to six black cross-bands. The lower surfaces are yellowish-white.

Length to anus...............................1070 mm.
Length of tail to base of rattle...... .... 90 "

Distribution.—Northwestern Utah, also Idaho.

Remarks.—The seven specimens at hand from Utah all have 41 rows of scales. The same number of rows is found in two specimens from Blue Lake and Hood's Valley, Kootenai County, Idaho, which may be regarded as belonging to this subspecies. The only other specimens with 41 rows of scales of which I have record are one from Red Point, Placer County, California, and one from Fyffe, El Dorado County, California. These are to be regarded as instances of individual, or possibly geographical, variation in *Charina bottæ bottæ,* for other specimens from the same localities have 43 rows. It is these two Californian specimens which cause me to regard the two forms as subspecies rather than species. All other specimens from California, Nevada, Oregon, and Washington, of which I have records, have more than 41 rows of scales. Thus, of forty-seven specimens from these states, fifteen have 43 rows, twenty have 45, six have 47, and six have 49 rows. A specimen in the Paris Museum is said to have 43 to 45 rows and to be labeled "Utah Terr". In the light of the present evidence it seems probable that this locality is erroneous.

Type.—Cal. Acad. Sci. No. 46090, collected at San Jose del Cabo, Lower California, Mexico, by J. R. Slevin, July 31, 1919.

Distribution.—The Cape Region of Lower California.

Remarks.—These two subspecies seem to be alike in all important characters, except the one mentioned. This difference is not a constant one, but exists in so large a proportion of the specimens that it seems best to recognize it by name. The following table shows the number of specimens which have each number of granules at the point where there are fewest on each side of the head:

Granules between rostral and nasal...	1–1	1–2	2–2	2–0
Dipsosaurus dorsalis lucasensis......	273	25	53	...
Dipsosaurus dorsalis dorsalis........	22	12	171	1

It will be seen that these granules are 1–1 in 78% of the 351 specimens of *D. dorsalis lucasensis* as against 10% of 206 specimens of *D. dorsalis dorsalis,* and are 2–2 in 15% of the specimens of *D. dorsalis lucasensis* as against 83% of those of *D. dorsalis dorsalis.*

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BY

CHARLES P. ALEXANDER, URBANA, ILLINOIS

VI

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BY

M. C. VAN DUZEE

VII

Two New Species of Syrphidæ (Diptera)

BY

A. L. LOVETT

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Female.—Length, 5 mm.; wing, 7 mm.

Rostrum and palpi dark brown. Antennæ black throughout. Head dull brownish gray.

Mesonotal præscutum brown with three broad dark brown stripes; tuberculate pits and pseudo-sutural foveæ black, the former located at the level of the anterior ends of the latter; remainder of the mesonotum brownish gray. Pleura dull gray; two conspicuous tufts of long, light yellow hairs on the meso-pleura, the more dorsal of these lying between the bases of the wings and halteres. Halteres conspicuously light orange-yellow. Legs with the coxæ dull gray; remainder of the legs dark brown, the femora clothed with sparse, pale, appressed hairs. Wings brownish gray, the disk variegated with paler; base of the wing, costal and subcostal cells more yellowish; cell *2nd* R_1 beyond the stigma pale; veins dark brownish black. Venation: Sc_1 ending opposite r; Sc_2 far from the tip of Sc_1, the distance on R between the origin of Rs and Sc_2 being a little less than R_1 beyond r; r about equal to the section of R_2 before it; cell *1st* M_2 closed, long and narrow; basal deflection of Cu_1 at about one-third the length of cell *1st* M_2. Anal veins convergent, the *2nd anal* vein being sinuous on its outer end.

Abdomen dark brown, the lateral margins with conspicuous light yellow hairs. Ovipositor with the tergal valves strongly upcurved.

Habitat.—Washington.

Holotype, ♀ (No. 719), Paradise Valley, Mt. Rainier, altitude 5000-6000 feet, July 29, 1919 (C. L. Fox).

Ormosia paradisea is allied to *O. arcuata* (Doane) of the Eastern United States, but the coloration is darker throughout, Sc_2 closer to the origin of Rs than to the tip of Sc_1, and other characters.

Genus **Rhabdomastix** Skuse

Subgenus *Sacandaga* Alexander

The species discussed below is the fourth Nearctic form to be described. It should be noted in passing that the two European species of *Gonomyia, G. schistacea* (Schummel) and *G. læta* Loew, are in reality members of this genus and subgenus.

2. **Rhabdomastix (Sacandaga) fasciger,** new species

General coloration brown, the pleura gray; wings grayish, the stigma brown; an indistinct brown fascia along the cord; abdomen dark brown.

Female.—Length, 7-8 mm.; wing, 7.5-9 mm.

Rostrum and palpi dark brown. Antennæ dark brown. Head gray, more brownish medially.

small; outer appendage chitinized, the apex slender and strongly curved, the outer margin with several appressed teeth; inner appendage short, blunt, fleshy, the surface covered with setigerous tubercles, two or three of the setæ at the end of the appendage being much longer and stouter; at the base of the pleurites two elongate cylindrical arms, the larger of which is provided with rows of long, curved hairs. Gonapophyses appearing as flattened plates with their caudal lateral angle produced into a long, straight point.

Type of the sub-genus.—*Limnophila ultima* Osten Sacken (Northern North America).

The curious Tipulid that is here made the type of the new subgenus, *Neolimnophila,* flies in the autumn and less commonly in the spring and so may be expected to be double-brooded. The species ranges across the entire northern United States and Canada, to British Columbia and Alaska.

3. **Limnophila subaptera** Alexander

1917 *Limnophila subaptera* Alexander, Canadian Entomologist, vol. 49, pp. 207, 208.

One female specimen in the collection undoubtedly belongs to this species although it differs considerably from the unique male type. This specimen may be made the allotype.

Female.—Length, 16 mm.; wing, 2.4 mm.

General coloration light yellowish brown, the pleura with a faint grayish bloom. Legs comparatively stout, the coxæ but little pruinose; legs brownish yellow, the femora and tibiæ scarcely darkened apically; the terminal tarsal segments dark brown. Ovipositor with the tergal valves greatly exceeding the sternal valves in length, slightly upcurved, the tips subacute.

Allotype, ♀ (No. 721), Bubbs Creek Cañon, Kings River, Fresno County, California, altitude 9700 feet, July 9, 1910 (E. C. Van Dyke).

Allotype in the collection of the California Academy of Sciences.

Genus **Ulomorpha** Osten Sacken

The genus *Ulomorpha* was erected in 1869 (Monographs Diptera North America, pt. 4, pp. 232, 233) to receive the then

4. Ulomorpha quinque-cellula, new species

Size large (wing of the ♂ 9 mm.); general coloration shiny reddish yellow; cell M_1 of the wings present.

Male.—Length, 8–9.2 mm.; wing, 9–9.2 mm.

Rostrum and palpi yellowish brown. Antennæ rather elongate for this genus of flies, the first segment brown, sparsely gray pruinose; second scapal and the basal flagellar segments dull brownish yellow, the distal segments dark brown; flagellar verticils long. Head dark brown, gray pruinose.

Mesonotal præscutum shiny reddish yellow without apparent stripes; remainder of the mesonotum dull yellow. Pleura reddish yellow. Halteres pale brownish white, the knobs brown. Legs with the coxæ and trochanters yellow; femora pale testaceous brown, the tips narrowly dark brown, especially on the outer face; tibiæ pale testaceous brown, the tips narrowly dark brown; tarsi dark brown. Wings with a strong yellowish tinge; stigma indistinct; veins brown; macrotrichiæ in all of the cells beyond the cord and more sparsely in the centers of the outer cells to basad of the origin of *Rs*. Venation: *Sc* ending at about three-fourths the length of *Rs*, Sc_2 at the tip of the subequal Sc_1; *Rs* long, spurred at origin; cell R_2 sessile; veins R_2 and R_3 divergent; veins R_2, R_3 and R_{4+5} arising almost from a common point; *r* indistinct; *r-m* very long; cell M_1 present, much longer than its petiole; basal deflection of Cu_1 just before mid-length of cell *1st* M_2.

Abdominal tergites yellowish brown, the sternites a little paler.

Habitat.—California.

Holotype, ♂ (No. 722), Huntington Lake, Fresno Co., altitude 7000 feet, July 28, 1919 (E. P. Van Duzee).

Paratopotype, ♂.

5. Ulomorpha nigronitida, new species

Size rather large (wing of the ♂ 8 mm.); general coloration deep shiny black throughout; cell M_1 of the wings lacking.

Male.—Length, 7–7.8 mm.; wing, 8 mm.

Rostrum and palpi black. Antennæ black throughout; verticils long and delicate. Head black, very sparsely gray pruinose.

Thorax shiny deep black, including the pleura. Halteres with the stem pale brown, the knobs dark brownish black. Legs with the coxæ dark brownish black, the hind coxæ paler; trochanters dull yellowish; remainder of the legs black, the bases of the femora dull yellow, this coloration narrowest on the fore legs, broadest on the hind legs. Wings with a pale gray tinge, the bases more yellowish; the abortive anal vein behind vein *Cu*, yellowish; the macrotrichiæ in the cells of the wing basad of the level of the origin of *Rs* more sparse than in *U. pilosella* or *U. sierricola*, but very much heavier than in *U. vanduzeei*. Venation; *Sc* ending at about four-fifths the length of the long sector, Sc_2 at the tip of Sc_1, Sc_2 being about two-thirds as long as Sc_1; *Rs* long, gently arcuated at origin; cell R_2 sessile or very short-petiolate; vein R_3 diverging from vein R_2 and almost parallel with R_1 so that cell R_2 is nearly twice as wide as cell R_3 at the

mesonotal præscutum with four narrow brown stripes; wings brownish gray, the distal cells with conspicuous macrotrichiæ; abdomen brownish yellow, the lateral margins of the tergites with five dark brown spots; male hypopygium with the ninth tergite large, deeply notched medially; caudal margin of the ninth sternite produced caudad into two long, straight appendages that are tipped with stiff, yellow, spinous bristles.

Male.—Length, 12 mm.; wing, 12.5 mm.

Frontal prolongation of the head shiny brownish yellow, darker brown medially; palpi brown. Antennæ moderately elongate, if bent backward extending about to the base of the abdomen; scapal segments yellow, basal flagellar segments indistinctly bicolorous, the basal swelling dark brown, the remainder of each segment paler brown; distal flagellar segments uniformly dark brown. Head dark brown, paler behind, the front and anterior part of the vertex golden-yellow pollinose; along the inner margin of the eyes more grayish.

Mesonotum light brownish yellow, shiny, the præscutum with four narrow brown stripes; lobes of the scutum dark. Pleura shiny testaceous yellow. Halteres dark brown, the base of the stem pale yellow. Legs with the coxæ shiny yellow, the base a little infuscated, trochanters yellow; femora yellowish basally, broken before midlength. Wings with a strong brownish gray tinge; cells *C, Sc* and the space behind vein *Cu* yellowish; stigma dark brown; an obliterative area before the stigma, extending across the inner end of cell *1st* M_2; veins dark brown; conspicuous macrotrichiæ in cells R_2, R_3, and R_5; M_1 and *2nd* M_2 except the base, and the tips of cells M_4 and Cu_1. Venation: *Rs* long, arcuated; vein R_2 persistent; petiole of cell M_1 shorter than *m*; *m-cu* at about one-fourth the length of cell *1st* M_2, the first section of M_{3+4} being shorter than that section of M_{1+2}.

Abdomen shiny brownish yellow, the hypopygium darker, especially the base of the ninth sterno-pleurite; conspicuous dark brown spots near the basal lateral margin of tergites three to six and near midlength of tergite two. Male hypopygium moderately large. Ninth tergite large, the caudal margin with a large, subquadrate median notch, the conspicuous lateral lobes flattened, the ventral surface concave, hollowed out like a spoon, directed caudad; base of the notch weakly rounded outward, the dorsal surface being impressed at this point. Pleural suture very short, straight; outer pleural appendage elongate, cylindrical, narrow basally, the distal two-thirds clothed with conspicuous, long, erect, black bristles. Ninth sternite with the caudal margin produced posteriorly into two very conspicuous straight appendages that lie parallel and close together, the surface at the tip and along the proximal face densely set with conspicuous yellow spinous bristles; the lateral margins with more erect black bristles. Dorsad of the base of these appendages and at the origin of the inner pleural appendages are two conspicuous, pale, fleshy lobes that project strongly laterad. Eighth sternite with the margin weakly trilobed medially, each lateral lobe provided with about two small setæ.

Habitat.—California.

Holotype, ♂ (No. 725), Santa Cruz, June 1, 1919 (E. P. Van Duzee).

8. Tipula cahuilla, new species

General coloration of the head and thorax light gray, the former with a narrow brown median line; mesonotal præscutum with five narrow brown lines; scutellum with a capillary brown line; wings grayish subhyaline; stigma dark brown; the distal cells of the wings with conspicuous macrotrichiæ; abdomen dark gray, the tergites with two yellow sublateral stripes; male hypopygium simple; abdomen of female very long and slender.

Male.—Length, 9–12 mm.; wing, 9–11.3 mm.

Female.—Length, 17.5–18.5 mm.; wing, 11–12 mm.; abdomen alone, 13.5–14.8 mm.

Frontal prolongation of head dull yellow, light gray above; palpi dark brown. Antennæ with the first segment light gray; remaining segments dark brown; flagellar segments subcylindrical, weakly incised beneath. Head light gray with a delicate brown dorso-median stripe and a broad, whitish ring around the eyes.

Pronotum gray. Mesonotal præscutum gray, the interspaces between the usual stripes dark brown; there thus appear five narrow brown lines of which the lateral pair represent the margins of the gray lateral stripes; the median vitta narrower, dark brown, not attaining the suture; scutum gray, each lobe with a brown circular mark; scutellum brownish testaceous medially, gray laterally, with a capillary brown median line; postnotum light gray. Pleura light gray, indistinctly variegated with pale spots on the mesepimeron and across the dorsal margin of the sterna. Halteres brown, the knobs darker, the base of the stem pale. Legs with coxæ light gray; trochanters dark brown; femora brownish yellow, the tips dark brown; tibiæ brownish yellow, soon passing into brown; tarsi dark brown. Wings grayish subhyaline, cell *Sc* a little yellowish; stigma conspicuous, dark brown; veins dark brown; numerous macrotrichiæ in the apices of cells R_3, R_5, M_1, *2nd* M_2 and M_4. Venation: *Rs* gently arcuated; cell *1st* M_2 small, pentagonal; petiole of cell M_1 a little longer than *m*; *m-cu* punctiform, located at about one-fourth the length of cell *1st* M_2.

Abdominal tergites dark gray with two conspicuous sublateral yellowish stripes, the caudal and lateral margins of the segments broadly pale; sternites dark gray, the caudal margins of the segments conspicuously pale. Male hypopygium of very simple structure. Ninth tergite broader than long, the caudal margin with a broad V-shaped notch, the lateral angles obtusely rounded; tergite not fused with the other sclerites of the hypopygium. Ninth sterno-pleurite extensive, the two pleural appendages very simple in structure, the outer one an oval, fleshy lobe that is covered with very short pile; inner appendage still smaller, bifid at the base, the outer branch small, black, the inner branch produced into a cylindrical beak. Ninth sternite with a profound, narrow, median notch. Eighth sternite unarmed. In the female, the abdomen is unusually long and slender, as will be seen by the accompanying measurements; the yellow abdominal stripes are very conspicuous. Ovipositor with a conspicuous dorsal shield; tergal valves broad basally, lying transversely, the outer margins entire; sternal valves much shorter, the tips truncated.

Habitat.—California.

Holotype, ♂ (No. 726), Atascadero, San Luis Obispo Co., April 26, 1919 (E. P. Van Duzee). Allotopotype, ♀ (No. 727), same data.

Paratopotypes, 1 ♂, 1 ♀; paratypes, 2 ♂'s, 2 ♀'s, Bradley, April 27, 1919 (E. P. Van Duzee).

This interesting little species would seem to be allied to *Tipula beatula* Osten Sacken. Its closest relative is *T. bituberculata* Doane, in which species the abdomen of the female is of normal length.

9. **Tipula evidens**, new species

General coloration shiny obscure yellow, the præscutal stripes scarcely apparent; antennal flagellum dark brownish black; wings grayish subhyaline, the costal region more yellowish; abdomen yellow, tergites two to five with conspicuous rounded black spots along the lateral margins, basal sternite with a conspicuous rounded black median spot; male hypopygium large, the ninth tergite very extensive with two obtuse submedian and two longer sublateral lobes; eighth sternite with two brushes of rather short yellow hairs.

Male.—Length about 14 mm.; wing, 15.5 mm.

Frontal prolongation of the head rather long, light brown, slightly darker at the base; palpi dark brown. Antennæ moderately elongated, if bent backward, extending about to the wing-root; scape and basal half of the first flagellar segment obscure yellow the remainder of the flagellum dark brownish black. Head dull brownish yellow, the center of the vertex more brownish gray pruinose.

Mesonotal præscutum shiny yellow with three indistinct reddish stripes, the surface covered with a sparse pollen; remainder of the mesonotum obscure yellow. Pleura yellow. Halteres yellow, the knobs dark brown. Legs with the coxæ obscure yellow; trochanters yellow; femora brownish yellow, the tips narrowly dark brown; tibiæ light brown; tarsi darker brown. Wings grayish subhyaline; cells *C* and *Sc* more yellowish; stigma light brown; an obliterative area extending from before the stigma across the inner end of cell *1st* M_2; veins brown. Venation: petiole of cell M_1 a little longer than *m*.

Abdomen yellow; tergites two to five with a conspicuous black rounded spot on the lateral margins, on the second segment near mid-length, on the other segments close to the base of the segment; sternites yellow, a conspicuous, rounded black spot on the first segment and less distinct marks near the posterior margins of segments two and three. Male hypopygium large. Ninth tergite very long and extensive, the caudal margin with a deep median notch, the adjacent submedian lobes broadly rounded and with the inner margin set with small setigerous tubercles; the sublateral margins of the tergites are produced caudad into much longer lobes, with the apices subtruncate, the notch between these and the

Abdomen obscure yellow, the basal segments brighter; caudal margin of the tergites narrowly ringed with paler; hypopygium reddish. Male hypopygium very large and powerful. Ninth tergite very powerful, tumid, the lateral angles produced caudad into elongate-triangular horns that are slightly twisted, the extreme tips acute, bent slightly laterad and dorsad; the median notch is broadly U-shaped, on either side of the median line with a small, chitinized, flattened projection, the apices obliquely truncated. Ninth sterno-pleurite very restricted between the large ninth tergite and eighth sternite, the pleurite almost complete. Outer pleural appendage slender, clavate, pale, provided with long bristles. Gonapophyses projecting from the genital chamber as straight chitinized rods. Eighth sternite with two brushes of short yellow hairs, one on either side of the median line; lateral angles produced proximad into pale, complex arms that are branched at their tips, the cephalic arm jutting backward underneath the ninth sterno-pleurite, the tip provided with a brush of hairs, almost like those on the caudal margin of the sternite.

Habitat.—California.

Holotype, ♂, Claremont (C. F. Baker), in the collection of the author.

Tipula megatergata is closely allied to *T. tergata* Doane and *T. sternata* Doane, especially the latter, but differs in the details of structure of the male hypopygium.

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VI

THREE NEW SPECIES OF DOLICHOPODIDÆ (DIPTERA) FROM CALIFORNIA AND NEVADA

illard

BY

M. C. VAN DUZEE

1. **Porphyrops montanus,** new species

A small blackish species with blackish wings and black feet.

Male: Length, 3.3 mm. Face narrow, silvery white. Front violet with two spots of white pollen which form a transverse band near its middle. Antennæ black; third joint of the usual acute triangular shape, not quite as long as the eye height; the apical arista about two-thirds as long as third joint. Lateral and inferior orbital cilia white, a few of the upper cilia black.

Thorax dark green, not very shining; pleuræ dulled with whitish pollen. Abdomen bronze or coppery-brown with a little blue or greenish on the center of the dorsum of the first and second segments, and rather long white hair on the sides of the first three segments. Hypopygium black, extending about one-half its length below the abdomen, its lamellæ black, slender, rather wide at base but abruptly narrowing and tapering to a slender point, not quite as long as the third antennal joint, fringed with delicate pale hairs on both edges and with two long black hairs at tip; inner appendages small, black with a point at tip and a tuft of black hair near the base. Legs and feet black; fore and middle tibiæ a little yellowish on upper surface of apical two-thirds; fore coxæ with long white hair on their anterior surface; fore basitarsi widened a little at tip into a small spur, making it a little concave below, a little shorter than the remaining four joints taken together, fourth joint very short. Calypters, their cilia, and the halteres yellow.

Wings strongly tinged with blackish; third and fourth veins bent so as to approach each other beyond the cross-vein, still nearly parallel at their tips.

Female: Color and wings as in the male. Face wide with white pollen, through which the green ground color can be seen; third antennal joint short, a little longer than wide, triangular; the apical arista longer than the antennæ. Front violet, narrowly blue or green just above the antennæ and along the orbits; fore coxæ with shorter hair than in the male; fore basitarsi not concave below, their tips not widened.

Described from one male and three females taken at Huntington Lake, Fresno Co., California, July 9, 1919, at 7000 ft. elevation, by Edward P. Van Duzee.

Holotype (No. 729), male, and allotype (No. 730), female, in the Museum of the California Academy of Sciences.

This species is very much like *P. mundus* Loew, but it is smaller and the female is more wholly black, the male has the lamellæ long and slender, while in *mundus* they are small and rounded; the inner appendages are small in this species and altogether black while in *mundus* they are long and yellowish; the third antennal joint is shorter in this than in *mundus*.

2. **Gymnopternus californicus**, new species

Male: Length, 3.2 mm. Face wide, covered with brown pollen. Front dark blue-green, almost black. Antennæ black, third joint scarcely pointed at tip, about as long as wide. Orbital cilia wholly black.

Thorax and abdomen greennish black, shining; hypopygium and its lamellæ black, the latter small, crescent shaped, fringed with brown hairs.

Legs and feet wholly black, the knees a very little yellowish; middle tibiæ with one bristle below and four above, all rather long and slender; middle and hind femora each with one preapical bristle, the latter with rather long hair on the upper edge, which is longest near the base. Calypters and halteres yellow, the former with black cilia.

Wings tinged with blackish; rather evenly rounded on the posterior margin, the anal angle being rounded off, not at all prominent; third and fourth veins a very little convergent at their tips, still the tips far apart.

Female: Agrees with the male in color and in the form of the wings. The face is wider and a little more gray than in the male; the hair on the upper edge of the hind femora is much shorter. The fore tibiæ with a row of little bristle-like hairs on their upper surfaces which are quite conspicuous; there are also three or four longer bristles among these hairs.

Described from 11 males and 18 females, taken at Huntington Lake, Fresno Co., California, July 9, 1919, at 7000 ft. elevation, by Edward P. Van Duzee.

Holotype (No. 731), male, and allotype (No. 732), female, in the Museum of the California Academy of Sciences.

3. **Gymnopternus convergens,** new species

Male: Length, 3 mm. Face wide, covered with dark brown, almost black, pollen. Front greenish black. Antennæ black, third joint longer than wide, somewhat oval, the arista inserted above the tip; orbital cilia wholly black.

Thorax and abdomen very dark green, shining, the latter with slight bronze reflections. Hypopygium and its lamellæ black, the latter crescent shaped, fringed with brown hairs on outer edge.

Legs and feet black, the fore and middle tibiæ more brownish; middle and hind femora each with two preapical bristles; middle tibiæ with two small bristles below and about six rather short ones above. Calypters and halteres brownish yellow; the latter with yellow knobs and the former with black cilia.

Wings tinged with brownish gray; third and fourth veins convergent towards their tips, which are rather close together; anal angle of wing rather prominent, the base of the wing being at right angles to the costal line; wing widest about half way from tip of fifth to tip of sixth vein, the hind margin being somewhat flattened from that point to the anal angle.

Female: Color and form of wing about as in the male, but the anal angle of the wing is a little less prominent. The middle and hind femora have each two preapical bristles as in the male; the face is a little wider and perhaps a little more grayish.

Described from four males and five females taken by the writer at Wells, Nevada, June 6, 1915.

Holotype and allotype in the author's collection. Paratypes in the collection of the author and in that of the California Academy of Sciences (No. 733).

PROCEEDINGS

OF THE

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VII

TWO NEW SPECIES OF SYRPHIDÆ (DIPTERA)

BY

A. L. LOVETT

1. Myiolepta carbicolor, new species

Length 10 mm. Color black: face, legs and pile black, thorax shining blue-black; third segment of antennæ light brown, arista black; wings dark smoky, veins black, halteres smoky brown.

Male: Face projecting, shining black, except for tubercle covered with dense whitish pollen; along eye margins and on greyish cheeks with sparse moderately elongate white pile; frontal triangle shining black, bare; vertical triangle black with elongate black bristle-like pile, the pile extending outward along occiput. Antennæ brown, black at base, the third segment light brown, circular; the arista moderately elongate, black.

Thorax and scutellum shining metallic blue-black with moderately dense, elongate black pile. Abdomen sub-opaque black with translucent brown and blue reflections arranged as pseudo-crossbands on anterior margins of segments. Pile on disc inconspicuous, short, black, on lateral margins and on fourth segment longer, white.

Legs black throughout, pile mostly white; on hind femur short, coarse, black; on hind tarsi, golden. Wings dark smoky, veins black; calipter with fringe of white pile; halteres smoky brown.

Type, male (No. 734), in Museum of California Academy of Sciences. From Longmire Springs (Mt. Rainier 2500 ft.), Washington, July 18, 1919; C. L. Fox, collector.

Another male from Paradise Valley (Mt. Rainier 5500 ft.), July 28, 1919, collected by C. L. Fox, in author's collection.

This species is near *auricaudata* Will, and *aurinota* Hine, but the wholly black legs and pile distinguish it.

2. Xylota bivittata, new species

In size, general appearance, and abdominal markings similar to *analis.* Legs without spur on hind coxæ. Antennæ lighter in color, third segment yellow, arista black, longer than with *analis.* Face brown, light yellowish brown on lower half, pile white; contour of face similar to *analis,* more deeply concave in profile, oral margin more pronounced.

Thorax with a pair of indistinct longitudinal vittæ not reaching the scutellum. Pile of thorax shorter, more golden than in *analis,* crossband of black evident only in certain lights. Opaque black of second and third abdominal segments narrower, margined with brown; yellow areas larger, quadrate, more as in *subfasciata.*

Legs without spur on hind coxæ, color markings similar to *analis,* the lighter areas more extended and honey-yellow; front and middle tibiæ except for brown ring, all tarsi except apical segments, honey-yellow. Wings similar to *analis,* apical cross-vein curved backward for a shorter distance and less abruptly; halteres honey-yellow.

Type, male (No. 735), in Museum of California Academy of Sciences, Huntington Lake, California, July 21, 1919; E. P. Van Duzee, collector.

Paratype, male, in author's collection.

Superficial characters throughout very similar to *analis,* abdominal markings resemble *subfasciata.* Light brown face, light antennæ and absence of spur serve to differentiate it, and minor characters are specific.

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VIII

Notes on Some Undescribed Californian Helices

BY

S. STILLMAN BERRY

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PROCEEDINGS

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CALIFORNIA ACADEMY OF SCIENCES

FOURTH SERIES

VOL. X, No. 8, pp. 53-70, pls. 4-6 AUGUST 11, 1920

VIII

NOTES ON SOME UNDESCRIBED CALIFORNIAN HELICES

BY
S. STILLMAN BERRY

Gradually accumulating material of the larger land snails of the Californian area enables the recognition, as so notorious in the case of the birds and mammals, of a considerable number of more or less strongly marked geographical races, descriptions of some of the more interesting of which are offered herewith. This paper is therefore to be taken as complementary to one published by the same writer in the University of California publications of a few years ago (Berry, :16). Unfortunately the earlier paper was not illustrated, as the figures prepared for it proved unsatisfactory for reproduction. The opportunity is now taken, at least in part, to make good the deficiency.

The writer's thanks are due to the various collectors hereafter mentioned who have so generously aided him by supplying specimens, as well as to Mr. John Howard Paine for the remarkable photomicrographs which constitute two of the plates.

August 11, 1920

Epiphragmophora tudiculata allyniana, new subspecies

(Plate 4, figs. 1a–1c)

Diagnosis: Shell moderately thin, low-conic to depressed-globose, strongly umbilicate, the umbilicus narrow and steep-walled, but permeable to the apex and having a diameter of about one-eleventh the major diameter of the shell. Whorls about 6, convex, the last strongly inflated and somewhat descending in front. Aperture rounded, ample, and very oblique, its deflection about 40°. Edges of peristome converging and connected by a thin parietal callus. Periostracum quite glossy, but roughened over most of the later whorls by numerous fine incremental lines and a very fine, close malleation like small hammer dents, the latter becoming obsolete on the higher portions of the spire and in the immediate vicinity of the umbilicus.

Color a dull cinnamon or Prout's brown, becoming yellower and paler in the umbilical region, and with a dark liver brown band of a width of about 1.5 mm. on the shoulder, bordered above and below by a light yellowish-brown band of about equal width with the dark band and with its mate opposite, or the lower in come cases a little the wider.

Measurements:

	Maximum diameter mm.	Minimum diameter mm.	Altitude mm.	Diameter umbilicus mm.	Number of whorls
Type	32.0	25.5	20.0	3.0	6
Paratype in C. A. S. Coll.	29.4	24.3	19.3	2.6	6¼
" Smith Coll..	32.3	25.8	18.8	2.7	6
" Berry Coll. " 4851	29.3	23.3	17.5	2.7	6
" Smith Coll..	26.3	21.5	16.6+	2.7	6

Type: Cat. No. 4850, Berry Collection. Paratypes in the collection of the California Academy of Sciences and Cat. No. 1969, collection of A. G. Smith.

Type Locality: Jasper Point, Mariposa County, California; Allyn G. Smith, May, 1917; five living adults taken.

Remarks: This large and fine race cannot be confused with any of the described subspecies of *tudiculata,* unless it be the *E. t. umbilicata* Pilsbry from San Luis Obispo County. The latter is likewise a relatively depressed, finely malleate, umbilicate form, but is well distinguished from its Sierran relative by its smaller, less tumid, heavier, and much more solid shell, lighter color, more conspicuous banding, and more polished surface.

Epiphragmophora traskii chrysoderma, new subspecies

(Plate 4, figs. 2a–2c)

Diagnosis: Shell as a whole depressed-conic in outline, moderately thin; whorls convex, the body whorl quite tumid. Umbilicus narrow, deep, little flaring, permeable; contained about eleven times, or a little less, in the diameter of the shell. Aperture only moderately oblique (30°). Peristome little thickened; only slightly reflected except over the umbilicus, the circular outline of which it barely indents; edges connected by a thin callus.

Nuclear whorls worn in type, but in other specimens very finely papillose and radially wrinkled, with obliquely slanting lines of larger, more regular, distant papillæ superimposed. Following whorls very finely wrinkly-papillose, usually more or less eroded. Growth lines as a rule comparatively weak, but stronger at sutures and becoming very strong on body of later whorls. Definite spiral sculpture hardly recognizable till latter part of fourth turn, but developing on fifth whorl into a somewhat wrinkly system of incised spiral lines visible to the naked eye, though more or less cut up by the intersecting growth lines; on the body whorl the whole complex strongly developed over its upper portion, becoming gradually weaker, but still very distinct, on the base.

Periostracum very thin, strongly dehiscent and almost impossible to preserve in dry specimens; very light golden brown (honey yellow of Ridgway) in color, sometimes showing streaks of a darker hue following the stronger lines of growth, but without any distinct spiral banding or other evident pattern. Shell beneath the periostracum pure white.

Measurements:

	Maximum diameter mm.	Minimum diameter mm.	Altitude mm.	Diameter umbilicus mm.	Number of whorls
Type	24.3	20.0	15.5	2.2	$5^3/_4$
Paratype	26.0	21.3	16.4	2.4	$5^3/_4$
"	24.6	20.3	15.7	2.3	$5^3/_4$
"	22.7	18.7	14.2	2.1	$5^2/_3$
Average	24.4	20.7	15.45	2.25	$5^3/_4$

Type: Cat. No. 4132, Berry Collection. Paratypes in the collection of the California Academy of Sciences and the private collection of George Willett.

Type Locality: Among loose talus on higher portion of southern end of South Coronado Island, Lower California; George Willett, December 13, 1918; 12 specimens.

Remarks: The Coronado Islands have for long been the reputed home of a snail belonging to the *traskii*-group of *Ephiphragmophora* which passed for many years as the *Helix carpenteri* of Newcomb, but Bartsch has lately reminded us that Newcomb's shell is almost certainly a mainland race of quite different affinities, and has therefore renamed the island subspecies *coronadoensis* (Bartsch, :16, p. 617), an action with which I am in accord. As there seemed to have been no collections of *coronadoensis* made within recent years, and the exact island of the group from which it came in the first place is still uncertain, Mr. George Willett took advantage of a brief visit to South Island in December, 1918, to undertake a special search for this snail. At first only the common *E. stearnsiana* (Gabb) was encountered, but finally in the southern part of the island, he found not only a thriving colony of what I take to be typical *coronadoensis,* but also a considerable number of specimens of the somewhat larger, pale-colored form here described. At the time, although found in a colony of its own, Mr. Willett took the latter to be merely an "albino" mutation of the other. This it may essentially be, but there are grounds, nevertheless, for believing that it represents considerably more than simply a sporadic variant.

Some readers will no doubt recall, as a previous attempt to give systematic recognition to an albinistic variation of one of

our Californian snails, the ill-fated *Helix anachoreta* of W. G. Binney. This is now considered by most authors, no doubt correctly, not to represent a fixed race, but to have been based on a chance light-colored variant such as is known to crop out ephemerally now and then in the race history of many diverse groups of organisms. Hence it has never been shown to inhabit any particular region or station, other than that regularly occupied by its "normal" prototype, *E. nickliniana* (Lea), or its occurrence to be any more than sporadic; in other words it does not seem to have become hereditarily persistent anywhere.

With *chrysoderma* it appears to be quite otherwise. In the first place, this light colored race, so far as the evidence goes, actually does constitute a definite colony in a definite locality and station on the island, as is indicated by "A" in the accompanying rough sketch received from Mr. Willett, namely among loose talus high on the slopes near the southern end of the island. Typical *coronadoensis,* I understand, was taken more or less sparingly with it, but proved more abundant on grassy slopes lower down and nearer the end of the island, where *chrysoderma* failed to recur. In the second place, the differences, though by no means great, appear to be fairly constant within the limits of the considerable series of both forms seen, and not confined to the dilution or lack of periostracal coloring alone. A comparison of the two series brings out the following special peculiarities of *chrysoderma,*—1) the *very thin,* strongly dehiscent periostracum (an exaggeration of a feature already present in some degree in *coronadoensis*), 2) the notably larger average size*, 3) the *light brownish-golden color* of the periostracum, 4) the *lack of spiral color bands* of any description, and 5) the more tumid outline of the body whorl. Possibly also the umbilicus averages slightly wider. The animal is light bluish gray in color.

Although I have recently described a curious little albinistic *Vertigo* (Berry, :19, p. 48), it was scarcely expected so soon to encounter another instance of an apparently hereditarily fixed albinism in a West American land snail. Very possibly both instances are more properly called albinoids than true

* The largest of 12 fully matured *coronadoensis* measures: Maximum diameter 24.1, minimum diameter 20.0, altitude 15.7, diameter of umbilicus 2.1 mm.; whorls $5^3/_8$. The average values of all the dimensions are: Maximum diameter 22.86, minimum diameter 18.95, altitude 14.78, diameter of umbilicus 1.87 mm.; whorls 5.60.

albinos. The true nature of such forms among the Mollusca is not yet well worked out, although in any event they are of considerable theoretical interest. Very few races of snails are distinguished by characters of such a nature as to strongly suggest their probable origin as sudden breaks or "mutations" of the DeVriesian type in the germ plasm of the ancestral form. But from the evidence at hand it appears quite reasonable to believe that the racial features of these two forms can be so regarded.

Epiphragmophora traskii willetti, new subspecies

(Plate 4, figs. 3a–3c)

Diagnosis: Shell depressed-conic, conspicuously umbilicate, the umbilicus deep, permeable to the apex, and having a diameter about one-ninth to one-eighth the greater diameter of the shell. Whorls about 6½ or a trifle less, convex, the last descending somewhat in front. Aperture ample and very oblique (45°). Edges of peristome converging and connected by a very thin, transparent parietal callus. Lip but little thickened, everted somewhat throughout, but especially at the pillar where it is sufficiently reflected to indent somewhat the otherwise circular outline of the umbilicus.

Color varying from near Prout's brown to tawny-olive, becoming a little paler and yellower in the umbilical region, and with a clear-cut, deep, liver brown band of a width of about 2.2 mm. on the shoulder, bordered below by a light yellowish band (near naphthalene yellow of Ridgway) of about equal width and above by a much narrower, slightly less clear-cut band of the same color.

Periostracum somewhat glossy and with a peculiar sheen. Lines of growth very numerous and quite regular. First half whorl delicately hyaline and nearly smooth except for a few weak incremental waves, with a fine weak papillation sometimes superimposed; next whorl and a half very finely and closely granose or wrinkly granose, with numerous, large, elongate, rather distantly spaced papillæ superimposed, the latter arranged fairly definitely in retractively curved, very obliquely slanting series; papillæ on later whorls nearly, or quite, obsolete; spiral sculpture consisting of a weakly developed series of

Its chief taxonomic features are the large size, depressed spire, wide umbilicus, weakly developed spiral sculpture (especially on the base), rich brown color, and prominent spiral banding.

Dead shells of what appears to be the same subspecies are before me from Sespe Canyon above the mouth of Tar Creek, collected by Harold Hannibal, and from Matilija Canyon, collected by H. N. Lowe, in May, 1919. Both localities are in Ventura County.

Epiphragmophora petricola orotes, new subspecies

(Plate 4, figs. 5a–5d; plate 6)

Diagnosis: Shell thin, translucent, depressed-conic, conspicuously umbilicate, the umbilicus deep, permeable to the apex, and having a diameter about one-ninth the greater diameter of the shell. Whorls about 5½, convex, the last descending somewhat in front. Aperture oval and very oblique (45°). Edges of peristome converging and connected by a thin, very delicate, parietal callus. Lip but little thickened and only very slightly reflected save at the pillar, where it tends to cover the edge of the umbilicus.

Periostracum more or less glossy, often showing quite a high polish. Lines of growth fine and numerous. First half turn weakly radially costate, with a few scattered papillæ; next three-fourths of a whorl finely, closely granulose, with fine, weak incremental costations, and, over all, traces of larger papillæ; granulation present to some extent on all remaining whorls, but of diminished importance as compared with the suddenly much increased incremental lines and the papillæ; latter now seen to be ranked, at least primarily, in the usual obliquely retractively slanting series, almost quincuncially arranged, but the appearance of regularity often lost; maximum development of these papillæ attained on the upper surface of the third whorl, still strong on the penultimate whorl, but practically absent from the body whorl except along the suture and within the umbilicus; spiral sculpture very poorly developed, only a few interrupted traces of incised threading being distinguishable on the upper third of the last two whorls, even these becoming entirely obsolete below.

Color a warm golden brown, running fairly near a tawny-olive, becoming a little paler and yellower on the base, and with a conspicuous dark (liver brown) band of a width of about 1.5 mm. on the shoulder, bordered above and below by a rather narrower band of a few tints lighter than the body of the shell.

Measurements:

	Maximum diameter mm.	Minimum diameter mm.	Altitude mm.	Diameter umbilicus mm.	Number of whorls
Smith Coll. (3700 ft.)	21.6	17.8	12.1	2.3	$5^2/_3$
Type	20.4	17.0	11.4	2.3	$5^1/_2$
Chace Coll.	24.5	20.5	14.0	...	...
Berry Coll. 3988....	22.1	18.3	12.5	2.4	$5^1/_2$
" " "	21.2	17.5	12.+	2.3	$5^1/_2$
" " "	21.0	17.2	11.8	2.4	$5^1/_2$

Type: Cat. No. 3905, Berry Collection.

Type Locality: Altitude 2500 feet, near trail, south fork of Warm Spring Canyon, San Bernardino Mountains, California; under logs; Allyn G. Smith, December 26, 1917; one specimen.

Additional Localities: Alt. 3700 feet, near trail just southeast of summit, Warm Spring Canyon, San Bernardino Mountains, California; Allyn G. Smith, December 26, 1917; two specimens.

Alt. 6500 feet, west wall of Bridal Veil Falls Canyon near mouth, above Forest Home, San Bernardino Mountains, California, in talus; E. P. Chace, May 24, 1918; nine fully mature living specimens, several dead and young. (No. 3988 above are part of this lot.)

Remarks: This neat little helicoid is practically a miniature race of the large *E. petricola* Berry (:16, p. 107), with which alone it would seem to require any special comparison. From this it differs not only in its much smaller size, but also in its thinner shell, more polished periostracum, and still further reduction of the spiral sculpture. It occurs in the same general region of the San Bernardino Mountains as the typical form, but has only been discovered at localities farther into the mountains, at all of which it appears relatively constant and quite sharply separable from *petricola.*

For purposes of comparison figures of the shell and microscopic sculpturing of the type specimen of *petricola* are here appended (Plate 4, figs. 4a–4c; plate 5), especially as this species has recently been strangely misunderstood by Bartsch (:16, p. 612), who referred it without qualification to *E. traskii traskii* (Newcomb). As a matter of fact very few of the numerous races described by him in the same paper have nearly the claim to separate recognition that *petricola* has, although I believe with him that most of them will stand. *E. petricola* is in fact the earliest described prototype of a whole series of southern Californian mountain snails, the exact relation of which to true *traskii* still remains to be determined. *E. zechæ* Pilsbry (:16), on the other hand, seems quite close to *petricola*.

Both *petricola* and *orotes* are distinctly papillose over much of the upper surface. A very young *petricola* now at hand from the type locality (Cat. No. 3950, Berry Collection) shows that, when perfect, each papilla bears a minute, stubby, hair-like periostracal process.

Epiphragmophora petricola sangabrielis, new subspecies

(Plate 4, figs. 6a–6c)

Diagnosis: Shell low-conic, thin, fragile, rather tumid, umbilicate; the umbilicus rather narrow, barely permeable to the apex, and with a diameter about one-twelfth the greater diameter of the shell. Whorls 5½, convex, the last swollen and slightly descending in front. Aperture rounded, sometimes slightly flaring, oblique (40°). Edges of peristome slightly converging and connected by a very thin, transparent parietal callus. Lip only slightly thickened; everted near the pillar so as to indent the circular outline of the umbilicus.

Periostracum somewhat glossy, often with a strong satiny sheen or semi-iridescence. Lines of growth numerous and fairly strong, though somewhat irregular. First half whorl when unworn showing rather strong, more or less interrupted, incremental wrinkles, and traces of a strong, coarse, overlying papillation; succeeding turns very finely wrinkly-granulose beneath the retractively slanting lines of small and at first often nearly obsolete papillæ, the latter increasing in strength to the

penultimate whorl where they are always strongly evident as well as within the umbilicus and to a less degree over the region just behind the aperture on the body whorl; papillæ elsewhere on the last whorl more weakly developed. Spiral sculpture obsolete, a few weak traces persisting on the upper surface and peripheral region of the body whorl only.

Color light golden brown near buffy citrine, paler and with more of a yellow tone below, with a dark, liver brown band of a width of about 1.0-1.5 mm. on the shoulder, bordered above and below by a rather narrower band slightly lighter in tone than the body of the shell.

Measurements:

	Maximum diameter mm.	Minimum diameter mm.	Altitude mm.	Diameter umbilicus mm.	Number of whorls
Type	26.3	21.0	15.7	2.2	5 1/2
Paratype, Willett Coll.	23.8	19.1	13.8	2.3	5 1/8

Type: Cat. No. 4848, Berry Collection. Paratypes in the collection of George Willett. (Neither specimen quite fully mature.)

Type Locality: Monrovia Canyon, San Gabriel Mountains, California; George Willett, March, 1919; 14 specimens, for the most part not quite mature.

Additional Localities: In addition to the lot from which the type was selected, the following specimens before me are possibly referable to the same subspecies. They are at any rate very close, although the material is still inadequate for entire certainty.

Millard's Canyon, north of Pasadena, San Gabriel Mountains, California; E. P. Chace, March 11 and June 3, 1917; one living adult, one living juvenal, seven dead of various ages.

Eaton's Canyon, north of Pasadena, San Gabriel Mountains, California; E. P. Chace, September 3, 1917; two living adults, six dead of various ages.

West fork San Gabriel River "just below the divide", San Gabriel Mountains, California; E. P. Chace, September 1, 1918; five dead shells.

Remarks: This mountain race appears to be somewhat similar to Bartsch's *avus* in shape, size, and the narrow umbilicus, but differs in the *weak* papillation of the upper surface, and the presence of a weak spiral sculpture. From *zechæ* Pilsbry, it is distinguishable by its thinner, more tumid shell, much narrower umbilicus, and the better developed papillation of the upper whorls. None of the other described races appears to require any special comparison.

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EXPLANATION OF PLATES

(Note: Figs. 4a-5d on Plate IV, and Plates V and VI, are from photographs by John Howard Paine. The remaining figures on Plate IV are from photographs by Berton W. Crandall.)

EXPLANATION, PLATE IV

(All figures natural size.)

Figs. 1a-1c. *Epiphragmophora tudiculata allyniana*, new subspecies. Anterior, apical, and basal views of type specimen, from Jasper Point, Mariposa County, California.

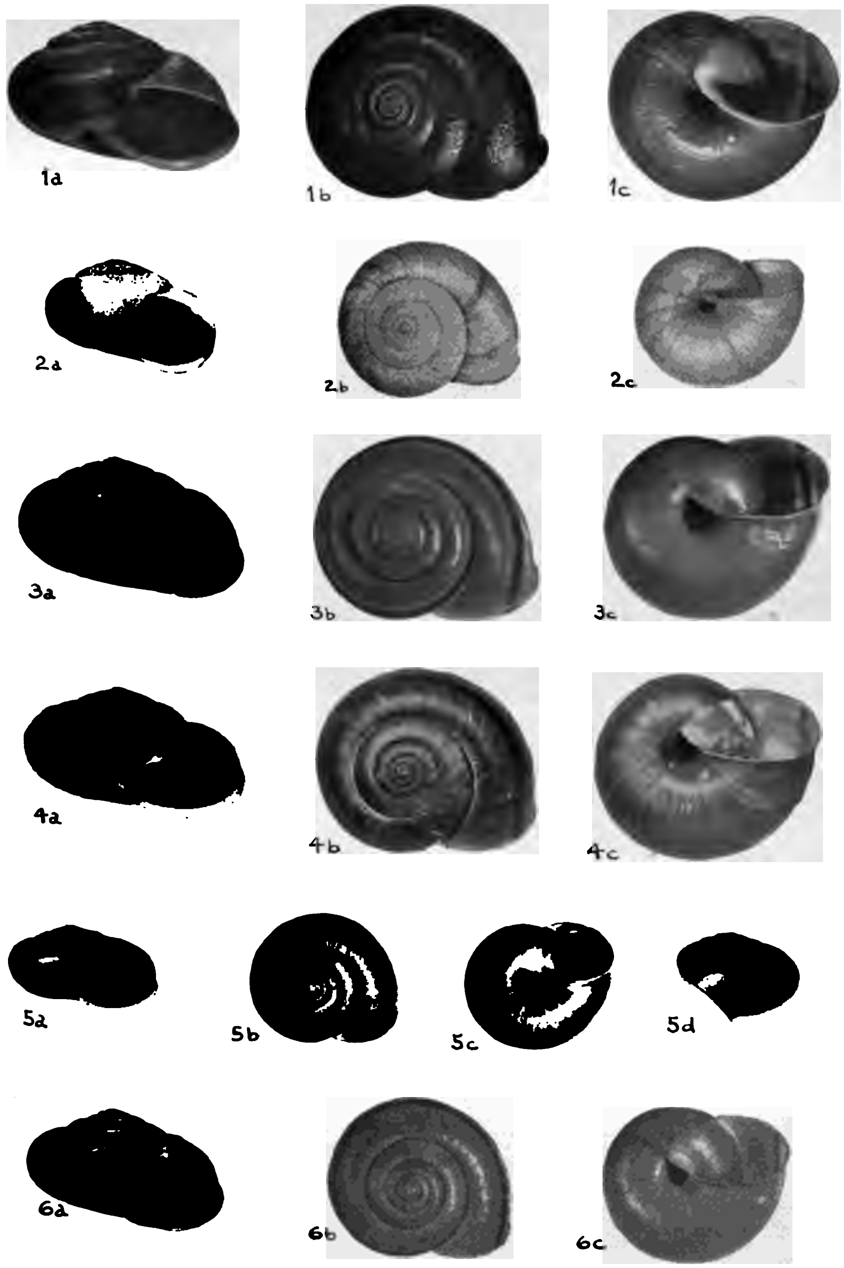
Figs. 2a-2c. *Epiphragmophora traskii chrysoderma*, new subspecies. Anterior, apical, and basal views of type specimen, from South Coronado Island, Lower California.

Figs. 3a-3c. *Epiphragmophora traskii willetti*, new subspecies. Anterior, apical, and basal views of type specimen, from Pine Canyon, Sespe Creek, Ventura County, California.

Figs. 4a-4c. *Epiphragmophora petricola* Berry. Anterior, apical, and basal views of type specimen, from Mill Creek Canyon, San Bernardino Mountains, California.

Figs. 5a-5d. *Epiphragmophora petricola orotes*, new subspecies. Anterior, apical, basal, and lateral views of type specimen, from Warm Spring Canyon, San Bernardino Mountains, California.

Figs. 6a-6c. *Epiphragmophora petricola sangabrielis*, new subspecies. Anterior, apical, and basal views of type specimen, from Monrovia Canyon, San Gabriel Mountains, California.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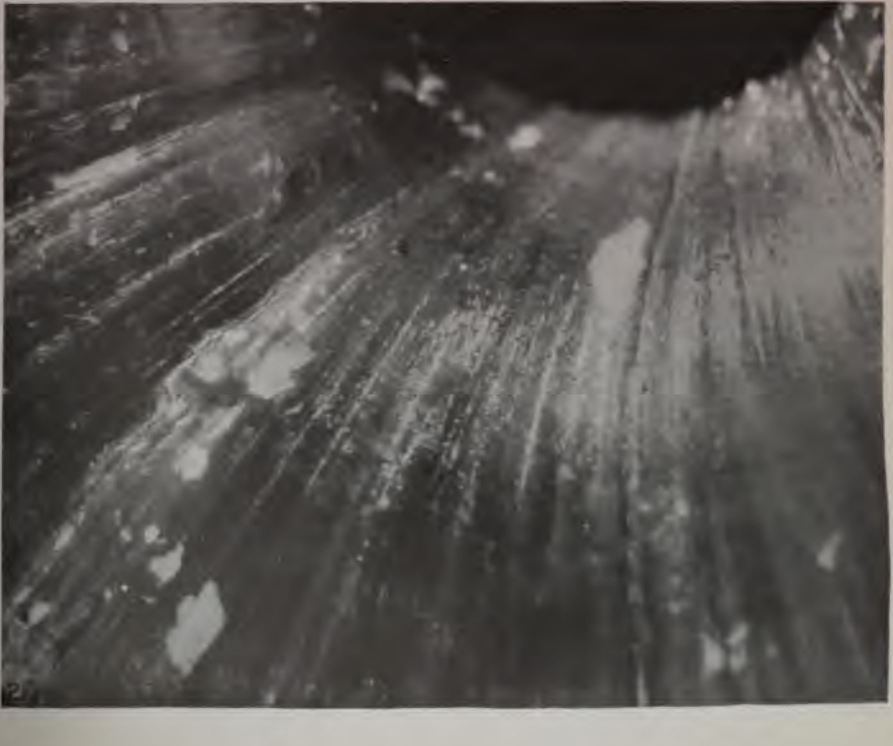
EXPLANATION, PLATE V

Fig. 1. *Epiphragmophora petricola* Berry, type. Portion of upper surface of last whorl about a quarter of a turn behind the aperture, showing periostracal sculpturing magnified about 15 diameters.

Fig. 2. *Epiphragmophora petricola* Berry, type. Portion of basal surface of last whorl about a quarter of a turn behind the aperture, magnified about 15 diameters.

1



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Explanation, Plate VI

Fig. 1. *Epiphragmophora petricola orotes*, new subspecies, type. Portion of upper surface of last two whorls a short distance behind the aperture, magnified about 20 diameters to show the periostracal sculpturing.

Fig. 2. *Epiphragmophora petricola orotes*, new subspecies, type. Portion of basal surface of last whorl just behind the aperture, magnified about 20 diameters.

Fig. 3. *Epiphragmophora petricola orotes*, new subspecies, type. Portion of apical region, magnified about 20 diameters to show the periostracal sculpturing.

(All photographs used on this plate reversed.)

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A NEW GENUS AND SPECIES OF GRASSHOPPER FROM CALIFORNIA

BY

MORGAN HEBARD

In the spring of 1917 (April 22-27), Mr. E. P. Van Duzee, curator of Entomology, Museum California Academy of Sciences, collected at Bryson in Monterey County, California. Among the material taken was a single specimen of grasshopper, which seemed to represent an undescribed genus and species.

Upon being informed of this fact, Mr. Van Duzee again visited Bryson, May 16-23, 1920, in order to obtain, if possible, additional material of the species. After considerable effort he was able to locate the habitat, and secured three additional specimens, all females.

Esselenia,[1] new genus

The present genus shows a combination of characters which makes it most difficult to place. The form of the insect is more robust than that of any other North American Acridid; in fact, it is of a type quite similar to that usual in the Ommexechinæ.

The head is as full, with face as perpendicular, as in *Stirapleura,* the pronotum showing a generally similar construction of the lateral carinæ. The lateral foveolæ of the vertex are, however, not visible from above, in this feature agreeing with *Mesochloa* and *Phlibostroma,* the vertex itself being as broad as in the latter genus and intermediate between them in showing a subobsolete medio-longitudinal carinula. The antennæ

[1] The small Esselenian tribe of Indians once inhabited the region from which this genus is known.

are relatively heavy and flattened, much as in *Mesochloa* and *Cordillacris,* though not showing the slightly greater flattening proximad found in those genera.

The pronotum, with caudal portion of disk produced mesad and laterad and margin between concave, is distinctive. In *Mesochloa* and *Psoloessa* alone do we find mere traces of concavity of the lateral portions of the caudal margin of the pronotal disk.

The inner spurs of the caudal tibiæ are almost equal in length, in this agreeing with *Cordillacris,* but not as long and slender as in that genus.

The ovipositor valves are very short, as in all the other genera referred to above.

Taking all into consideration, we believe that *Esselenia* should be placed after *Phlibostroma,* though further study of the proper order of the related genera may lead to its being placed near *Stirapleura.* The system generally in use for the linear arrangement of the genera of the Acridinæ is clearly unsatisfactory, but can not be rectified until extensive studies of the subfamily are made.

Genotype.—*Esselenia vanduzeei,* new species.

Figure 1.—*Esselenia vanduzeei,* new species. Dorsal view of type. Female. (X 3)

wrinkled, this decided toward the lateral carinæ. Lateral lobes of pronotum with greatest depth equal to dorsal length; cephalic margin weakly convex and scarcely oblique to the obtuse-angulate, sharply rounded ventro-cephalic angle, ventral margin broadly convex to the rather broadly rounded, rectangulate, ventro-caudal angle; caudal margin broadly concave; sulci deeply impressed on lateral lobes.

Tegmina represented by broadly lanceolate pads with rounded apices, which are attingent (or weakly overlap), nearly as long as combined length of head and pronotum. Veins and cross-veinlets of tegmina heavy and distinct, forming a coarse and irregular network, in which, however, the principal veins, and particularly the humeral vein, are clearly defined.

Short ovipositor valves with heavy apices sharply curved. Caudal femora heavy, the ventral and particularly the dorsal portions evenly and broadly lamellate, the lamellation of the dorsal margin being over half as wide as the external pagina.

Measurements (in millimeters)

Female	Length of body	Length of pronotum	Caudal width of pronotal disk	Length of tegmen	Width of tegmen	Length of caudal femur	Width of caudal femur
Type	20.2	5.6	4.8	8.1	3.8	12.	3.5
Paratype	22.2	6.	5.3	8.1	4.	12.1	3.9
Paratype	20.2	5.6	5.	8.	3.8	11.7	3.7
Paratype	20.8	5.	4.4	7.6	4.	11.8	3.7

General coloration (type, intensive) dark chestnut brown. Head paling to hazel on occiput, cheeks tawny, this continued as a U-shaped band from eyes, its lower portion crossing the labrum, frontal costa and ventral portion of infra-ocular sulcus suffused with black. Antennæ hazel, deepening to chestnut brown distad. Pronotum with median carina russet, bordered by a band of mars brown, lateral carinæ buffy tinged with russet, this broadening into a band on the metazona, the triangular areas between these and the medio-longitudinal band velvety blackish brown. Lateral lobes of pronotum irregularly paling to tawny meso-proximad and with a buffy callosity mesad which extends as a narrow line ventro-cauded to the caudal margin above the ventro-caudal angle. Tegmina pecan brown, the veins of the dorsal field suffused with black. Ventral surface of abdomen argus brown. Cephalic and median limbs hazel, mottled with chestnut brown. Caudal femora light ochraceous-tawny in proximal two-fifths, this terminated in external face of dorsal surface by a large triangular patch of

velvety blackish brown, this surface flecked proximo-dorsad with this color also; remaining distal portions pecan brown, suffused in genicular areas with blackish. Caudal tibiæ opposite genicular areas of caudal femora black, beyond this showing a broad buffy annulus, particularly distinct on the inner surface, remaining portions buckthorn brown, suffused distad with mummy brown; proximal internal spines mummy brown, other spines and spurs buckthorn brown, tipped with mummy brown.

One of the paratypes is similarly colored, except that the general coloration is much paler, walnut brown. Another has the color pattern much more strikingly defined, the blackish areas being as dark, but the medio-longitudinal band of head and pronotum light ochraceous-tawny, the tegmina ochraceous-tawny except in the sutural half of the dorsal section and the proximal portions of the caudal femora light ochraceous-salmon. The remaining paratype is almost uniformly sayal brown in coloration, the dark triangle dorsad on the caudal femora remaining as the only trace of color pattern.

In addition to the type, three female paratypes are before us, bearing the same data, but taken May 18, 1920. One of these is the property of the California Academy of Sciences, the other two are in the author's collection.

In securing these paratypes, Mr. Van Duzee had some difficulty in locating the proper environment in which to search for the species. They were taken in the same canyon as the type, on the grassy or sandy borders of a small mountain stream. At the time there was no running water in the stream, but little pools with level sandy flats between and it was on one of these flats that all were located. The exact spot is in the canyon back of the Bryson school house, about two miles east of the Nacimiento River and the same distance north of the San Luis Obispo County line.

The species probably reaches its greatest adult abundance in the early spring.

We take pleasure in naming this singular species in honor of the ardent student and collector who discovered it and who has subsequently, not without considerable difficulty, secured additional material and valuable data as to the immediate environment in which it occurs.

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X

Color Changes and Structure of the Skin of Anolis carolinensis

BY

CHARLES E. VON GELDERN

SAN FRANCISCO
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(Gadow), is produced at will in the mid-ventral region of the head and neck. This fan is produced by the hyoidean apparatus. The mechanism of this apparatus consists of a double, tapering cartilage lying in the mid-ventral line and attached to the body of the hyoid just anterior to a line through the center of the eye. When erected, it carries the loose skin of the cervical region with it.

This throat-fan is, according to Ditmars, purely ornamental and produced only by the males, being accompanied by a vigorous nodding of the head and neck.

It is produced when a male spies a female or when it prepares for combat with another male. When the males are captured and held in the hand, this fan becomes prominent. Often when two males meet, each one will erect a ridge along the mid-dorsal line extending from the base of the occiput to a variable distance along the back. This may be accompanied by a marked lateral compression of the thorax and abdomen so that the lateral diameter is smaller than the dorso-ventral, whereas under ordinary conditions the reverse is true. The throat-fan is usually very prominent during this state and there is present a characteristic coloration which will be described later.

The Anolis lives well in captivity when supplied with water in the form of scattered droplets and flies or meal worms. It soon becomes apparently very tame and will take insects from the fingers of its captor.

Observations of Color Changes in the Living Anolis

A general fact impresses itself after one has captured and observed many of these lizards in captivity, namely, that the range of variation in the color of the skin is by far greater in those animals which have been freshly captured. After a few weeks of captivity, although seemingly in perfect health, the color changes become less complicated and less brilliant. This observation may tend to explain the differences noted by different observers as to the color changes. Ditmars states that the color varies from different shades of brown to emerald green and that although these are the common hues of Anolis, other hues are striking, namely, golden yellow and slaty gray with the peppering of white spots over the back. These colors he believes occur during the transition from the two extremes, namely, brown and green. Carlton states that

he has never seen any changes other than the different shades of brown to emerald green and bases his assumption that the color changes are much more simple in Anolis than in the true chameleon, on the observations of Lockwood.

To those observing these lizards in their natural environment, it is evident that the variation is not so simple as has just been noted. A slaty gray with no element of brown or green is of fairly common occurrence, as is also straw yellow.

Furthermore over certain areas of the body the colors undergo even a greater variation than is ascribed to them by Ditmars. Over the mid-dorsal region, for instance, there is present in many of these lizards a narrow stripe of two or three millimeters in width, extending from the cervical region to the sacrum or even along the tail for a variable distance, in which further variations may be noted. That this stripe varies in different individuals is probable, and it may even be absent. Nevertheless, it is so characteristic of many specimens that a description of its changes should not be neglected. A bright pink color is often present along the stripe which may become darker until it assumes a brick-red color conveying the impression that there is placed there a thick pigment which does not belong to the skin. This stripe may also show a cream color or white, containing a faint suggestion of yellow or brown. This light color is most often observed in those lizards which have assumed the brown hue elsewhere on the body.

When the mid-dorsal stripe assumes either a pink or a white stripe it is irregular at the edges and these irregular edges are dark brown. A less irregular, black stripe is often observed in the green state.

I have been unable to discover any rule for the appearance of the dorsal stripe in its various states. It may be present or absent, brick-red, pink, white, or black in different lizards living under the same conditions, nor does the color state of the rest of the body influence the appearance to any extent. I believe that this stripe may appear at some time in all the animals in which it is absent, but that its appearance entails considerable change in the structure of the skin so that its production must necessarily be a slow one.

On the sides of the maxilla, posterior to the eye there may be present a black, quadrangular patch, measuring in large males about two by three millimeters. When present, this patch is of shiny black appearance and differs markedly from the rest of the

body even in the dark brown state. This patch appears during the time when two males are preparing for combat and is associated with the appearance of the mid-dorsal ridge, the lateral flattening of the abdomen and thorax, the extension of the legs so that the body is raised off the ground, and by a peculiar greenish mottling of the skin. The altered appearance of this animal preparing for combat, in color, form and action, shows such marked changes, that it is difficult to associate it with the animal under ordinary conditions. Even the eyes, which ordinarily are fairly prominent, recede so that the palpebral fissures show only the pupils. The movements are slow and awkward and the body may sway from side to side in a most fantastic manner.

In general, the peppering of white spots on the dorso-lateral aspect of the body is characteristic, especially during the brown state, and these spots may be confluent on the lateral aspect of the cervical region. The lower border of the maxilla, the entire mandible, and the ventral aspect of the entire body varies from a snowy white to dirty brown, gray, or peppered with black dots. The throat-fan when extended is a brilliant pink or vermilion and over it are scattered many white spots. When relaxed, the skin of the throat region is somewhat cream colored or white with reddish streaks at times.

The following table indicates the various colors noted in different specimens at the same time and in the same specimen at different times:

TABLE SHOWING RANGE OF COLORS IN VARIOUS AREAS OF THE BODY

I Dorso-lateral aspect:
- A Diffuse:—
  - *a.* Golden yellow to straw yellow.
  - *b.* Emerald green to dirty bluish green.
  - *c.* Slaty gray of various shades.
  - *d.* Light brown to dark mahogany brown.
- B Mottled:—
  - *a.* Yellow with irregular patches of green.
  - *b.* Yellow with irregular patches of brown.
  - *c.* Emerald green or pea green with irregular areas of darker green to brown.
  - *d.* Green or brown (usually the latter) peppered with white or light turquoise blue spots.

He also found that the green state could be produced in three ways, namely, by subjecting the animals to the absence of light, by inhibiting the blood circulation, and by cutting off the nerve supply.

Inhibiting the circulation, he found, was a more important factor than cutting off the nerve supply, in that it brought about more rapidly the green state and, furthermore, when both factors acted simultaneously, still greater rapidity in change occurred than when either one acted alone.

Carlton believes that the green state represents the unstimulated state of the skin, which is suggested by the fact that ether narcosis, nicotin poisoning, and death are associated with the green state. The brown state, he believes, is brought about by stimulation of the nerve endings and represents "the state maintained through tonus established by the sympathetic nerves and dependent upon stimulation of the nervous end organs in the skin by light."

Parker and Starratt, repeating Carlton's experiments on the rapidity of change from one color state to another, obtained results that were not uniform and found that changes would occur more rapidly on one day than on another and even at different times during the same day.

By means of a constant temperature apparatus which could be illuminated at 115 candle-meters and at the same time brought from 10°C. to 50°C., they found the average length of time at various temperatures at which either the brown or green state could be produced from the opposite color state. They found that at 10°C., the skin remained brown in either light or dark, but as the temperature was raised to 20°C., the animals placed in the dark became green in 19.66 minutes. At 25°C., under the same conditions, the change took place in 13.23 minutes; at 30°C., it took 10.93 minutes; at 35°C., 15.48 minutes. At 40°C. to 45°C., the skin remained greenish gray to green in both light and darkness.

On the other hand, when green lizards were placed in the light at 20°C., the brown state was brought about in 4.23 minutes; at 25°C., 3.52 minutes; at 30°C., 3.13 minutes, and at 35°C., 2.8 minutes.

These investigators believe that at intermediate temperatures, namely, between 20°C. and 35°C., light is the controlling factor but that temperature is effective over this range is evident in that it may influence the rate of change.

Parker, in experimenting with *Phrynosoma regale*, found that the claw-like scales which fringe the lateral edge of the body became white when the animal was subjected to a temperature of 32°C. and placed in the dark, and when placed in the light these claw-like scales became almost black. At 19°C., these scales became black in 15 minutes when the animal was placed in the light, and they became white in 30 minutes in the dark. At 15°C. light again caused black, while darkness brought about a light color, but not white. From these results he concluded that a low temperature favored the production of the black state, whereas a higher temperature, the white state. Thus light produces in this animal, as in Anolis, a dark state, while its absence brings about the light state.

Parker further believes that even in Stellio, Uromastix, and Veranus, which have always been considered to have a reversal of the light reaction, in that light causes just the reverse effect as in Anolis, namely, the production of light coloration in the light and dark coloration in the dark, that the apparent reversal is really a temperature effect and not a true reversal of the effect of light.

Parker and Starratt mention the observations of Doctor Caswell Graves who stated that in the neighborhood of Beaufort, N. C., on hot, sunny days about as many green lizards as brown ones may be captured. These results are explained by Parker and Starratt by considering that some of the animals are more sensitive to light than to heat and thus become brown, while others are more sensitive to heat than to light and become green.

I do not believe that this explanation suffices, for if one notices individual lizards for a considerable length of time, one is struck by the frequent and rapid changes from green to brown and back again to green, apparently regardless of temperature and light. How much influence the otherwise varying nervous conditions exert on these color changes, it is difficult to say for it would seem almost impossible to control them. I have watched animals which were sunning themselves and apparently undisturbed and quiet undergo these changes in a rhythmic manner. Rapid changes are also frequently noticed when an Anolis changes slowly from one object to another, the change occurring while the transfer is being made.

Redfield, after numerous carefully checked experiments on *Phrynosoma cornutum*, was able to verify the conclusions of Parker,

Carlton, Starratt, and others that the daily rhythmic changes of color are produced by the direct action of light and heat upon the melanaphores. He further states that Phrynosoma adapts itself to its surroundings, namely, if placed on a substratum of white sand it slowly assumes a light coloration irrespective of light or heat and if placed on a substratum of cinders it slowly takes on a dark coloration. He concludes that the color adaptation depends upon stimuli received through the eyes.

He was able to bring about a pale coloration in various ways, such as forcibly opening the mouth or by the application of a weak faradic current to the mucous membranes of the mouth or cloaca. He believes that this proximal migration of the pigment may be brought about in two ways, namely, by nervous impulses which stimulate the melanophores through the sympathetic nervous system or by secretion of a hormone (adrenin) from the adrenals. The impulses are carried from the mouth or cloaca along the spinal cord to a center situated between eighth and thirteenth vertebræ and thence by sympathetic fibres to the adrenals. The stimulated glands secrete adrenin which is taken up by the blood stream and acts directly on the melanophores causing a proximal migration of the pigment.

Redfield concludes from the fact that adrenalin produces proximal migration of the pigment in Anolis and from the work of Carlton, that impulses through the autonomic nervous system cause a distal migration of the pigment, that the melanophores of Anolis must possess a double innervation from two divisions of the autonomic nervous system. That this is possible he shows by analogous tissue, namely, the smooth muscle, the latter one "known to be innervated by antagonistic fibres belonging to two morphologically distinct parts of the autonomic nervous system."

The explanation for emotional manifestations in Phrynosoma, Anolis and other animals is readily explained by his conclusions regarding the secretion of adrenin.

When first placed in captivity the brown and green lizards in the same cage are about equally divided, but after remaining in captivity for a few weeks the greater proportion become brown in the daylight and the green produced by the absence of light has lost its former brilliance.

Much has been written about the true chameleon and its adaptation of color to its surroundings. Keller found, after placing specimens of *Chamaeleon vulgaris* in a green house, that in a short space

of time he was able to find them only after a most careful search, in spite of the fact that when found they were often in plain view. However, he does not believe that the surrounding color plays any role but that other factors, which he did not attempt to explain, bring about these changes. Ditmars states that there is no relation between the color of Anolis and its surroundings.

One must have great temerity to deny such a statement, but I have noted adaptations to the surroundings in Anolis which seem to be more than accidental. For instance, I have noticed that on dark brown fence rails which contained small areas of green lichen, some of the lizards resting on them assume a dark brown color with irregular patches of brilliant green. In other words, a mixed state is often evident and the effect produced resembles fairly closely the surroundings. Almost invariably the lizards seen on the trunks of the palm trees in New Orleans are brown and are often detected with great difficulty.

The table below represents the findings on May 16, 1917, from 11.30 A. M. to 1.45 P. M., during which time the temperature was 25.5°C. The environment is stated, as well as the number of lizards noted thereon, and the intensity of their color state. G represents green and B brown. The sign + + + represents the greatest intensity of either green or brown, namely, either emerald green or mahogany brown, + + represents a less intense color but still quite marked, while + indicates the least degree of intensity but one in which one is able to definitely state the color as being either green or brown.

TABLE 2

	Number of green lizards			
	G +++	G ++	G +	Total G
Green foliage	0	2	6	8
Dark green foliage	1	0	1	2
Concrete	2	0	1	3
Brown tree trunk	0	0	2	2
Fence rail	2	3	6	11
Totals	5	5	16	26

	Number of brown lizards				
	B +++	B ++	B +	Total B	Total G & B
Green foliage	0	0	0	0	8
Dark green foliage	1	1	0	2	4
Concrete	1	2	0	3	6
Brown tree trunk	0	1	0	1	3
Fence rail	1	3	7	11	22
Totals	3	7	7	17	43

Except the lizards seen on green foliage, the number of green animals equals the brown ones. No brown ones were noted on green foliage but the observations here recorded are by far too limited to permit definite conclusions to be drawn. There was some difficulty in deciding whether an animal resting on a brown fence rail amid a mass of green foliage should be classed as one resting on a fence rail or on green foliage, but it was decided to place these with the former.

One is justified, however, in drawing one conclusion from the table, namely, that under approximately the same conditions of temperature and light both green and brown lizards may be found and, even on sunshiny days with a moderate temperature, the green ones may even outnumber the brown ones. According to Parker, brown should be the prevailing color. It does not appear that in their natural environment the reason for the greater number of green lizards can be accounted for on the ground that these animals reacted more strongly to temperature than to light.

According to Parker and Starratt, the Anolis remains brown at 10°C. and remains green at 40°C., regardless of light. One would expect then, that at a temperature of 25.5°C., if there were a greater susceptibility to temperature, the brown state would prevail for at this temperature there is active both the light and medium temperature influence.

Evidently a factor which is of extreme importance in influencing the color state is the emotional or nervous condition which can not be easily controlled. The effect of the organs of internal secretion which are under the control, directly or indirectly, of the nervous system probably also influences the color states.

Ditmars states that the sleeping Anolis is invariably green and that the same color is present during anger or fear. He states that if a cage containing a number of these lizards be shaken, all

take on the green state, but after allowing them to rest for a short time, most of them assume the brown state. I have found this to be true in general. Also, if a brown Anolis is taken out of its cage and held in the hand it becomes green in a few minutes. This characteristic change occurs quickly even in animals which have been kept in captivity for a number of weeks and have apparently become tame.

It is evident that various factors influence color states and the problem becomes even more complex when one considers that certain areas of the skin may be light colored, as in the case of the mid-dorsal stripe, while the rest of the skin may be dark. One must admit that the skin is influenced by three factors, temperature, light and emotional or nervous conditions, induced, no doubt, by way of sense organ stimuli. Yet we get opposite effects in two areas of the skin of the same animal. One would hardly expect light and temperature to have a selective action on the skin.

Structure of the Skin of Anolis

The chief object of this paper is to present a review of the histological structure of the skin of Anolis and to add some observations with the hope that the further investigation of the color changes may be enhanced and some of the factors governing the color states explained. It is not claimed that a knowledge of the minute structures and their relations will offer a full explanation of these changes, but without such a knowledge, physiological experiments must fail to accomplish this end. It is only by keeping in mind the structure of the skin that the actual processes involved may be surmized and physiological data be applied in actual explanation of the problems.

The skin of Anolis is comparatively thin and loosely attached except at the sides and dorsum of the head and tail. On closer observation it is seen that it is not smooth but is thickly studded with small, closely-packed scales which vary in shape, color, and size in different parts of the body. These small scales, designated as *scutes* by Carlton, are smooth and shiny.

The scales situated along the mid-dorsal line are irregular in shape and size with slight tendency toward a hexagonal outline (Fig. 1). They are well separated and measure 0.29 mm. lengthwise to the body and 0.305 mm. in the transverse direction. A thickened, linear, longitudinal keel may be present in the mid-line of the scale. The scales on the dorso-lateral aspect of the body are

less irregular than those along the mid-dorsal line and none shows overlapping. They measure 0.248 mm. x 0.265 mm. (Fig. 2). Those scales on the lateral aspect of the body are almost circular in outline and are arranged in two rows, vertical and horizontal, the intersection of the two rows making an angle of about 58°, and they measure 0.255 mm. x 0.248 mm. (Fig. 3).

The scales on the ventral aspect are larger and more closely arranged, the caudal edge of each scale overlapping slightly the cephalic end of the scale just behind it. The outline of the scale is somewhat oval or circular and there is present a horny ridge or keel extending down the middle which becomes more prominent as the caudal border is approached. The scales of the region measure 0.35 mm. x 0.36 mm. (Fig. 4).

The scales on the tail differ markedly from those previously described. They are hexagonal in outline and closely packed and overlap each other to a greater extent than those on the ventral surface. There is present a median ridge and the surfaces on either side slope away from it. These scales measure 0.45 mm. x 0.27 mm. (Fig. 5).

The dorsal aspect of the head is made up of bilaterally symmetrical plates of a more or less hexagonal form. Just posterior to the intersection of the mid-dorsal line and the posterior edge of the orbital ridge is a marked pineal eye. The scales on the distended throat-fan are widely separated and are flattened and somewhat conical in shape. Those of the eyelids are so minute as to be barely visible.

The color of the individual scales is the same as that described for the various areas of the body. When a general color state is assumed, for instance brown, isolated scales may be white, turquoise blue, lighter or darker brown than the general hue, or even green.

Some extremely interesting features are noted in scales on the various parts of the body when observed under the low power of the microscope, by reflected and by transmitted light. The characteristics exhibited by the scales present points of similarity, but also some very marked differences. For these observations bits of fresh skin were taken from different parts of the body and mounted in glycerin and the appearance of the scales was studied both from the external surface and from the internal surface.

The external surface of the lateral scales appears yellow by transmitted light. Scattered evenly throughout are somewhat indistinct, pale brown, stellate-shaped bodies, the melanophores,

which average about fifty in number for each scale. The spaces between the scales are transparent and contain many branching pigment cells (Fig. 6 A). By reflected light these scales appear emerald green and the interspaces black (Fig. 6 B). The internal surface appears blue by reflected light and the branching melanophores appear distinct and dark brown or black (Fig. 6 C).

The external surface of the scales of the ventral surface appears a pale straw color by transmitted light and contains isolated indistinct pale brown melanophores of from four to twelve in number. The branches of these melanophores become darker near their termination (Fig. 7 A). By reflected light the scales appear somewhat as inverted glass cups containing crushed ice and the melanophores are cobalt blue except at the termination of their branches which are brown (Fig. 7 B). The internal surface by transmitted light appears a pale straw color and the melanophores are distinct and black (Fig. 7 C).

The scales along the mid-dorsal stripe differ from those just described in that, irrespective of other colors, they have a peculiar pinkish cast while the melanophores are much fewer in number in many scales and lighter in color than those previously described.

The scales of the throat-fan are pale straw color by reflected light and show the blue appearing melanophores. The wide spaces between the scales present many bright red linear streaks of varying sizes which branch and anastomose. The underlying color is pink and of granular appearance. By transmitted light the melanophores appear brown and more distinct and the spaces between the scales take on an orange color. Injections of india ink into the circulation would tend to show that the pink color is not entirely due to the vascularity of this structure but to some other coloring matter present.

It would appear from the differences noted by reflected and transmitted light that the melanophores are separated from the surface of the scale by some substance which gives them a bluish cast by reflected light and pale brown by transmitted light. That they themselves are black is evident by viewing them from the internal surface of the scale where they present a sharp clear outline (Fig. 6 A, B and C). In order to explain the green color of the scales of the lateral aspect of the body it is necessary to eliminate the yellow coloring matter which is noted by transmitted light. This may easily be accomplished by subjecting the skin to alcohol and ether in which this yellow substance readily dissolves. When

the scales are now viewed externally by reflected light, they no longer have the green appearance, but appear deep blue just as do the previously described scales viewed from the internal surface by reflected light (Fig. 6 C). The melanophores, however, are blue and indistinct, indicating, as was later found, that a semi-transparent reflecting layer exists between them and the surface and that this layer is evidently not affected by ether or alcohol.

The explanation for the green color is now quite apparent, for blue rays are reflected and these in passing through a clear yellow medium present to the eye the green color.

The semi-transparent reflecting layer lying between the melanophores and the external surface reflects bluish-white light as is evident in those scales in which little or no coloring matter exists and in which the melanophores are sufficiently separated so as not to influence the reflected light to any extent. This is true of the scales on the ventral aspect of the body, in individual lateral scales, and the white ones often found along the mid-dorsal line.

HISTOLOGY

That the tissue relationship of the skin might be more carefully analyzed with the purpose of attempting an explanation for the changes of color, a number of lizards in various color states were killed and segments of the body fixed in different fluids. It was found that segments placed for about six weeks in a fluid consisting of 3.5% potassium bichromate 100 parts, formalin 4 parts, and glacial acetic acid 5 parts, gave the best results. Tissue fixed in this fluid maintained the cellular relationship and the osseous structures were sufficiently decalcified so that entire sections of the body could be made.

Formalin was found to act too slowly with segments of the body. Lizards in the green state became brown during its action. It was possible, however, to overcome this difficulty by injecting formalin quickly with a hypodermic needle under the green skin, thus obtaining almost immediate contact of the fluid with the entire internal surface of the skin. This method has a distinct advantage in that the animals may be studied on the table for a considerable length of time after fixation and the color state carefully recorded. Unfortunately, however, after a longer time the green color becomes changed to a slaty gray after the use of formalin, due most probably to a change in the yellow coloring matter. Removing the skin and washing it in water soon after fixing prevents this

bleaching and bits of skin may then be held between pieces of hardened celloidin and sectioned. The solubility of the yellow substance forbids imbedding in either celloidin or paraffin. These sections should then be mounted in glycerine.

For examination of the cellular elements, tissues imbedded in both celloidin and paraffin were sectioned at 15 microns and stained with haematoxylin and eosin. Frozen sections treated with gold chloride for the purpose of showing the nerve endings have, so far, not been successful.

In order that the histological picture be made as complete as possible, the elements of a single lateral scale will be described (Figs. 10, 11, 12, 13 and 14). Where differences exist in the scales of other parts of the skin these will be mentioned. The layers comprising the scale will be taken up in their order, beginning from without inward.

Epidermis.—The outermost, transparent layer or epidermis may be divided into an outer, horny layer or stratum corneum and an inner, stratum germinativum. The epidermis is considerably thicker near the summit of the scale than at the periphery where it becomes continuous with the thin epidermis of the space between the scales.

The stratum corneum may usually be divided into two layers, an outer one which is separated by an interspace from an inner. This outer layer represents that portion which is ready to be cast off in moulting (Figs. 8 and 12). The inner layer does not stain with eosin, being straw-colored. The squamous cells may show clear, non-staining, round bodies, representing the degenerated nuclei. The layer undergoes marked keratinization at the apex of the scale with the formation of a homogeneous, horny ridge or keel. This thickening is more marked in the scales on the ventral aspect and those along the mid-dorsal line. Keratinization of the other cells of the stratum corneum, other than in the keel, is not so marked and, due to the dehydrating effect of the air, become fairly well separated so that their outlines may be distinguished (Fig. 8).

Brücke has described "interference cells" in the outer layer of the stratum corneum in *Chamæleon vulgaris*. These cells, he believes, modify the color of the skin by reflected light to a very marked extent.

Keller believes that the outer cells of the outer layer of the stratum corneum contain minute closely placed columns arranged at right angles to the surface of the cell. He calls this outer layer

the "Relief Schicht," and the inner surface of this outer layer the "Negative Relief Schicht." The latter presents the negative picture of the former in that instead of minute columns there are toothlike incisions corresponding to the columns of the "Relief Schicht." The layer between these two he terms the stratum corneum. He further claims that the outer cells of the inner layer of the stratum corneum are similar to those of the outer layer and terms them the "Second Relief Schicht." He believes that separation occurs along a line corresponding to the boundary between the "Negative Relief Schicht" and the second "Relief Schicht" and that when the outer layer is cast off the second "Relief Schicht" becomes the first and then a second line of cleavage occurs making a second "Relief Schicht" and a "Negative Relief Schicht." This cleavage goes on at regular intervals. He found that the fine column-like structures of the cells were very much more pronounced in the foot pads and at the apices of the scales.

In Anolis the first or outer "Relief Schicht" of Keller is very prominent on the under surface of the adhesive pads of the second phalanges. The second "Relief Schicht" is also present when the outer layer of the stratum corneum is well separated from the inner layer, but no "Negative Relief Schicht" was noted. On the outer cells of the outer layer of the stratum corneum of the scales of the general body, occasionally minute spicules resembling short cilia may be seen in stained preparations but such occurrence seemed very rare. In dried scrapings, the outer cells seen on the flat contain numerous dots giving them a stippled appearance when examined with the high dry or oil immersion lens. These probably represent the spicules that Keller has described for the chameleon. (See Fig. 9.)

The stratum germinativum takes the haematoxylin and eosin well. The cells are polygonal with fairly large vesicular nuclei. In the scales this layer is from two to three cells thick but in the epidermis between the scales it is at most only two cells thick. The basal layer is composed of cuboidal and columnar cells with large vesicular nuclei. Their proximal borders, attached to an ill-defined basement membrane, are frayed and brush-like (Fig. 8).

That the epidermis, through phenomena of interference, exerts some modifying influence on the color of the skin in Anolis is without doubt, but that it plays the important role which Brücke ascribes to it for the chameleon is doubtful. Keller, in fact, disagrees with Brücke as to the importance of this layer even in the

chameleon. The small, transparent spicules in the outer layer possibly cause some diffraction of light but this must be slight for the underlying cellular outlines are markedly clear when viewed through the epidermis.

The Oil Droplet Layer.—A considerable amount of confusion exists in regard to the layer underlying the epidermis. Keller has described a layer in the chameleon which he designates the ochrophore layer. He does not believe that it is cellular for the elements composing it have no nuclei, but he believes that it is made up of bits of cytoplasm cast off from an underlying layer of cells which he terms the leucophore layer. This ochrophore layer is found on the dorso-lateral aspect of the body but is almost entirely absent on the ventral aspect and entirely so on the foot-pads and spaces between the scales. Keller found that the elements of the layer were brownish yellow by transmitted light and a bluish white by reflected light, had a granular appearance, and that they disappeared under the influence of mineral acids. He described these elements as more or less spindle shaped and vertically arranged, the ends in contact with the epidermis being more pointed than those of the opposite end. The elements farther removed from the epidermis had both ends rounded.

Pouchet called this layer "Iridocytes" and believed the elements to be cells although he could not make out the cellular structure.

In Anolis, Carlton describes what he believes to be the ochrophore layer of Keller. He admits that its structure is not similar to that found in the chameleon. I do not believe that Carlton saw a layer corresponding to that in the chameleon, but that he described the leucophore layer which he mistook for the ochrophore layer. I will take up my reasons for this assumption in the discussion of the leucophore layer.

In sections stained with haematoxylin and eosin, I was unable to make out any layer corresponding in either position, structure, or color to the ochrophore layer. In certain scales, more often those situated along the mid-dorsal line, a clear space or a space filled with large clear cells with large vesicular nuclei could be noted where the ochrophore layer should lie. Knowing that it was possible to dissolve out the yellow coloring matter in the scales with alcohol and ether, it did not seem improbable that in the preparation of the stained sections practically all trace of this layer had been lost.

racy. These cells were not described by Carlton, but Keller has described similar cells for the chameleon and named them zanthophores, and Pouchet also described similar cells for the chameleon and believed that they contained fat droplets of 2.5 microns. He believed these cells to be analogous to the yellow cells of batrachians and that they possessed the power of contractility. Keller also believed that they could expand or contract for he found them varying markedly in size. Doctor Irving Hardesty suggests that these cells secrete or control the accumulation of the oil droplet layer described above.

If Keller and Pouchet be correct in their assumption that these large clear cells may expand, one might reason that during this state they practically fill the entire space between the epidermis and the underlying layer and force the yellow droplet layer towards the periphery of the scale so that it no longer influences the color states.

For reasons which will be taken up later, I believe that the mechanism is not quite as Keller would have one believe, although undoubtedly these cells are more numerous and almost replace the oil droplet layer in the white scales of the mid-dorsal stripe. If these large, spherical cells in Anolis are the zanthophores of Keller, and they resemble very closely those he figures and describes, Carlton is wrong in stating that these cells do not exist in Anolis.

The Leucophore or Guanophore Layer.—The layer lying just beneath the layer of oil droplets presents very marked differences from any of the structures previously described. In vertically sectioned scales, stained with haematoxylin and eosin, it is seen that this layer is thicker near the center of the scale and then gradually thins out until it disappears at the periphery. The layer forms then an inverted cup which thins out at the edges and fits into the hollow epidermal scale but does not come in immediate contact with it because of the intervening oil droplet layer. It is present in all the scales of the skin including those of the ventral aspect of the body (Figs. 8, 10, 11, 12, 13, 14 and 17). By reflected light it appears as a homogeneous bluish-white band (Fig. 10 B), and this appearance is not lost in those sections fixed in the fluid mentioned and stained with haematoxylin and eosin. Bits of the layer may be found isolated in the deeper fibrous layer, recognizable by the bluish-white color.

By allowing a minimal amount of light to come through the condenser of the microscope, the layer has a most brilliant opalescent appearance. In unstained, freshly fixed formalin sections, by transmitted light, it has a pale brownish appearance (Fig. 10 A), but in stained sections it appears darker and greenish brown (Figs. 11, 12, 13 and 14).

Fig. 10, A and B, represents the appearance of an unstained section of the layer by reflected and transmitted light. By reflected light this layer appears as a bluish-white cloud which obliterates the underlying structures, or at least makes them appear hazy and indistinct.

In both the stained and unstained vertical sections the layer is seen to be composed of parallel rows of somewhat irregular blocks, their long axes being parallel to the outline of the epidermis. These blocks are of varying size and asymmetrical shape, and undoubtedly possess small, deeply staining nuclei. Some sections show these nuclei better than others. The vertical section gives little idea of their morphology for when seen in tangentially cut sections they appear very irregular in outline and possess short pseudopodoid processes which may terminate in hooklike expansions or branches. Every conceivable shape exists and no similarity exists in these bodies except in their marked irregularity (Fig 14). In some sections these cells appear syncytial, for their processes are in juxtaposition, thus leaving numerous openings of various sizes between these apparently joined processes. Through these openings run the branches of the melanophores (Figs. 14 and 17). That really no syncytium exists appears likely, for in vertical sections no such connections between the processes can be made out. When viewed from above, the area around the nucleus has a bluish cast while the periphery is a pale greenish brown.

One can conclude then that the cells of this layer are fairly thick, irregular plates of fairly uniform thickness throughout but with a marked irregular outline.

Carlton describes a somewhat similar layer in the scale of Anolis which he calls the ochrophore layer and which he considers analogous to the ochrophore layer of Keller for the chameleon. He believes that this layer produces the green color and finds that by reflected light it appears bluish green and by transmitted light yellowish green. From the micro-photographs accompanying his paper, one cannot be mistaken as to the identity of the layer in question. He has noted the block-like, parallel arrangement in

the vertical section and also the irregular appearance in the tangential section, stating that it had the appearance of a more or less homogeneous mass, irregular in outline, and penetrated in many places by the processes of the melenophores but he was unable to make out any cellular structure and denied the existence of nuclei except between the blocks. Why he should believe this layer to be the ochrophore layer of Keller, I am unable to say. He admits that its arrangement differs from Keller's ochrophore layer.

If Carlton's ochrophore layer is responsible for the green state in Anolis, why is this layer present on the ventral aspect of the animal where no green color is ever present?

Keller states that this ochrophore layer is almost entirely absent on the ventral aspect of the body of the chameleon, yet Carlton, in spite of these differences in structure and position, attempts to make these two layers analogous. Furthermore, Carlton's ochrophore layer closely fits the description of Keller's leucophore layer, which latter Carlton states does not exist in Anolis.

Undoubtedly the layer in Anolis is the same as that in the chameleon except for possibly minor differences.

Brücke described in the chameleon a white or yellow pigment which he finds separated into two layers, the inner being thicker and made up of closely packed colorless particles with rounded boundaries, which reflect light, resulting in the white appearance. He believes these reflecting granules to be the product of cells whose processes force themselves between the dermal structures and lie between the epidermis and the underlying connective tissue. In these two layers he evidently includes both the ochrophore layer and the leucophore layer of Keller.

Pouchet has also described this layer and considers the white, dust-like material as the products of cells which, by the growth of the neighboring tissue, have been pressed into plates, and Keller describes these plates or blocks which he names leucophores. He considers their content similar to that found in the scales of certain fish described by Kühne and which are said to be composed of guanine. The fact that both react positively to the murexide test leads to this assumption. He believes, as does Pouchet, that these leucophores have been pressed into plates by the pressure of the overlying and underlying tissues and that their edges adapt themselves to the neighboring structures due to the mechanical resistance of the latter, and, in consequence, assume very irregular

shapes except in those regions where no such pressure is exerted. In regions where no pressure is exerted, they are rounded and lie close together in the wide meshes of the connective tissue.

I was unable to verify Keller's observations that the leucophores were rounded in those regions where the mechanical resistance is less, for those isolated cells which were noted by me showed in reality even greater irregularity, when seen in vertical section, than those in the leucophore layer proper. That the peculiar plate or block-like shape and the arrangement of these in parallel rows may be due to the pressure of the dense connective tissue from below seems likely, but only careful observations of the skin in various stages of development can determine this point.

The white, dust-like material of Pouchet, the white pigment of Brücke, or the granules of Keller, which were described in the leucophores, were not noted by me in Anolis. The cytoplasm of these cells even in the fresh state was clear and apparently free from granules. This finding is interesting in that one would expect the reflecting power of these cells to be due to the denser granules, and probably such granules do exist but were invisible because of methods I employed in the study of these cells.

No differences in shape or position were noted in the leucophore layer in the green and brown state. The cells of the layer seem to retain their characteristic appearance and relationship no matter what color state of the skin existed. Carlton makes the same observation for his so-called ochrophore layer.

The blue coloration of the melanophores by reflected light described for the scales of the ventral aspect of the body is undoubtedly due to the leucophore layer as is also the white appearance of these scales. This will be touched upon later.

The Melanophores.—Lying between the leucophore layer and the underlying connective tissue layer, and partially imbedded in both, are the melanophores described by Keller for the chameleon (Figs. 10, 11, 12, 13, 14, 15, 16, 17).

In Anolis three types of pigment cells are found, namely, those in the dorso-lateral scales which differ from those in the ventral scales by their smaller size and more delicate branching, those in the ventral scales, and a third type which is commonly situated just beneath the epidermis between the scales. The melanophores show a striking resemblance to the Purkinje cells as seen in Golgi preparations. A line passing through the cell bodies of the majority of them would be more or less parallel to the epidermis except

at the periphery of the scale where they more closely approach the surface. A few cell bodies lie above or below this imaginary line, but in thick sections the bodies of the melanophores form a fairly thick, dark-brown layer of fairly regular width.

The melanophores are best studied in vertical sections of the fixed material stained with haematoxylin and eosin. It was found unnecessary to use the methods adopted by Keller and others to bring out the finer branches of these cells, for in most of the preparations these were clearly visible.

The cell body is more or less rounded but considerable difference exists among them, some being much narrower than others (Figs. 11 and 12). The surface facing the epidermis is often concave but rarely it may be convex or apical. The nucleus may be round, oval, reniform, horseshoe-shaped or even double in rare instances. In some preparations it takes a fairly deep blue stain and has a vesicular appearance (Figs. 11, 15 and 17). The concavity when present is directed towards the epidermis.

Coming off from the sides of the outer surface of the cell body are a varying number of permanent branches which run either vertically toward the inner surface of the epidermis or present a lateral curvature. The curvature may even be so marked that, at the proximal part, the branches may be directed first downwards and laterally and then gradually curve laterally and upwards (Figs. 11, 12, 13 and 15). These branches run through the spaces among the leucophores and, as they approach the surface, lateral branches in turn give off further branches. This tree-like branching continues until beneath the under surface of the epidermis a layer of fine terminal branches exists.

The contents of the melanophores consists of a varying amount of fine pigment granules imbedded in a mass of faintly brown, poorly staining cytoplasm. The arrangement and distribution of the pigment granules depends on the color state of the skin, being almost absent in the smaller branches in the green state but present even in the terminal branches in the brown state. Under the oil immersion lens the poorly staining cytoplasm may be followed even in the finest branches lying beneath the epidermis. Following them is, however, greatly facilitated by the presence of isolated pigment granules which have failed to migrate with the general mass of pigment.

The pigment granules are oval in shape and brown under magnification. Their number varies markedly, irrespective of the

distribution of the pigment. The number varies not only in melanophores in the same scale, but also melanophores of one scale may contain more pigment than those of another. Also the intensity of the color of the pigment may vary, individual or groups of melanophores containing a lighter brown pigment than others. This appears to be irrespective of the number of granules. These differences in amount and intensity in color are so striking that there is no doubt as to their occurrence (Figs. 11, 12 and 13).

In the green state of the skin of Anolis (Figs. 10 and 11) the pigment granules are present only in the bodies and proximal parts of the primary branches of the melanophores. This proximal migration of the pigment is practically complete and the finer distal branches are clear and transparent. In some of these finer branches, however, a few scattered pigment granules may have failed to follow the mass of pigment and their presence allows one to detect more readily the finer branches. The bodies of the melanophores during the proximal migration of the pigment are necessarily darker than after distal migration. In proximal migration of the pigment it is noticed in the primary branches of the melanophores that there is an area of gradation between the dense pigment on one side and the clear part on the other side where the pigment is much less dense. In this portion the pigment granules apparently arrange themselves in parallel rows (Figs. 11 and 15). This parallel arrangement has also been observed by Keller in the chameleon.

In the brown state (Figs. 12 and 13) the finest branches lying immediately beneath the epidermis are filled with closely packed pigment. This gives the appearance of a thin, dark-brown layer lying just beneath the epidermis in vertical section. One might conclude that, in order that this appearance can be produced, the terminal branches must anastomose and form a plexus. That this is not the case, however, may be readily determined in tangentially cut sections where the terminal branches appear as separated but closely packed, dark-brown dots (Fig. 14). Keller makes this observation for the chameleon and Carlton for Anolis.

It is probable that the green state of Anolis does not represent the maximum degree of proximal migration of the pigment. In certain scales, pigment may be absent even in the primary branches and be confined entirely to the cell body which appears like a dark brown or black sphere. Furthermore the pigment may be condensed to such a degree that a clear broad halo of cytoplasm may

surround a central compacted mass of pigment (Fig. 15 A and B). These peculiar melanophores are often bilaterally arranged and present in a group of from two to three scales on each side of the body. This bilateral arrangement appears too marked to be accidental. Melanophores in this condition must explain the yellow colors and white scales often to be observed in the living Anolis.

Besides the distal and proximal migration of the pigment, any degree of migration may be present, namely, all but the terminal branches may be filled with pigment, or the terminal branches may contain scattered pigment, and so on. All of these conditions influence the color state of the skin and must be associated with definite color states.

The number of melanophores varies considerably in the various scales, but the average for those of the lateral aspect of the body is about fifty in number. This number is greatly reduced in the scales along the mid-dorsal line which are white and in which ten to fifteen pale brown melanophores appear to be the usual number. The latter are slightly smaller and their branches are more delicate and spread out more than the others. In the mid-dorsal line of other specimens where no white stripe exists but where color changes resemble those of the lateral aspect of the body, the melanophores cannot be distinguished from the others and appear in about the same number.

The melanophores in the scales, on the ventral aspect of the body are from five to twelve in number. Their bodies are larger and more rounded and possess fewer primary branches. The terminal branches are followed with greater difficulty to the periphery. The pigment is usually thickly packed in the cell bodies giving the cells a dark-brown color. The nucleus due to this increased amount of pigment is rarely observed (Fig. 8).

The pigment cells lying in the spaces between the scales vary markedly in number and position and, aside from their possession of branches and pigment content, show little resemblance to the true melanophores (Figs. 11, 12, 13 and 16). They more nearly resemble ordinary mesenchymal pigment corpuscles. The body resembles a flattened disc as is readily seen by comparing the vertical diameter as seen in vertical section (Fig. 13) with the horizontal diameter as seen from above (Fig. 16). The primary branches are thick and irregular and vary considerably in length. The terminal branches are short and terminate broadly in club-like ends. The cells are present just beneath the epidermis between the scales,

their branches spreading out and lying parallel to it. These cells may often be found in the deeper tissues of the body and give the impression of their being able to wander between the tissues (Fig. 13). That these cells may be converted into melanophores seems possible.

That the pigment granules migrate in the fixed pseudopodic processes of the melanophores, instead of an amœboid extension of and retraction of the processes themselves, is very probable. This migration has been clearly illustrated by Keller and Brücke for the chameleon, Carlton for Anolis, Degner for *Praunus flexuosus*, Kahn and Lieben for *Rana temporaria* and Spaeth for *Fundulus heteroclitus*. Parker believes that the pigment migration is true for Phyrnosoma and, further, states that the migration of pigment in melanophores is influenced by light and temperature, either light or low temperature causing a distal migration and absence of light or high temperature causing a proximal migration.

Although fully agreeing that the melanophores and their processes remain fixed and that their pigment undergoes migration, I am unable to see how any set of factors influence all melanophores similarly. Under precisely similar conditions the melanophores of the lateral aspect of the body may contain proximally migrated pigment, whereas the melanophores of the mid-dorsal stripe or melanophores of isolated scales may have the pigment in the terminal branches. In a single animal, in any color state, many exceptions may be found to the rule laid down by Parker.

Gold chloride preparations repeatedly fail to reveal any nerve endings terminating on the bodies of the melanophores but that these exist seems most probable. Pouchet described a smaller pigment-bearing cell which he termed the erythrophore and which closely resembled the melanophore except that it contained a purplish-red pigment. Brücke overlooked these cells of Pouchet, but according to Keller, the cells only occur on the lateral scales of the chameleon in any great number and are not present in all individuals. Keller described gradation forms, cells containing both brown and red granules in different proportions. Some cells may contain only a few red granules among brown ones while others may contain only a few brown ones, the greater proportion being red.

Carlton was unable to find erythrophores in the skin of Anolis and denied their existence. I believe that Carlton is correct, for if these cells be present they must be extremely rare. No red pigment granules were observed in any melanophores of my sections.

It seems likely, however, that the pigment granules vary considerably in the intensity of their color as has already been stated. This conclusion is reached not only from a study of the pigment granules in the melanophores but also from their effect on the color of the skin. There is little doubt that a condensed mass of pigment will produce a darker brown than more scattered pigment, but the former will always be brown and can never be black or brick-red.

If this be true, then the melanophores producing the post-orbital black patch must contain black pigment granules and those producing the brick-red stripe must contain reddish-brown granules. Furthermore, it is possible that an individual scale may contain melanophores of two or more kinds of pigment content and that these may act independently of one another. This is suggested by the microscopic appearance as well as the appearance of either a brick-red, brown, or black state in the scales of the mid-dorsal and the post-orbital stripes. Undoubtedly the amount of pigment present plays an important role, but many of these differences cannot be satisfactorily explained. Partial distal migration may be responsible for a lighter brown color than maximal distal migration, but only up to a certain point. Any distal migration beyond this is not associated with a still lighter brown state but with a slaty or greenish-gray color.

The Connective Tissue Layer.—Lying beneath the leucophore layer, running into the concavity of the scale for a variable distance but approaching more closely the epidermis at the edges of the scale, is a fairly dense layer of white, fibrous connective tissue (Figs. 8, 10, 11, 12 and 13). The fibres appear to run parallel but on closer inspection many vertical and oblique ones may be noted. The vertical fibres may be traced as they ascend among the cells of the leucophore layer where they break up into small fibril bundles which form a network beneath the epidermis. This layer takes on a bright pink color with eosin and contains many deeply staining stellate and spindle shaped nuclei. It is fairly vascular and nerves may be seen traversing it. Below the concavity of the scale are present fat corpuscles and large blood vessels (Figs. 11, 12 and 13). Beneath the dense connective tissue separating the skin from the underlying skeletal muscles, there is present a loose areolar connective tissue. Fine free pigment granules forming a fine line between the denser connective tissue and the looser

areolar tissue, may be seen in many sections. Free granules of red color aid in giving the red color to the extended throat-fan.

The skin is extremely vascular but more so in some regions than in others. Larger vessels run beneath the denser connective tissue layer and run parallel with it, dipping into the scale. From these vessels branches are given off which run through the denser connective tissue and also through the leucophore layer to directly supply the epidermis (Fig. 13). It seems not improbable that a vaso-dilatation occurring under and in the leucophore layer, may exert a modifying influence on the color states. The pink color of the mid-dorsal stripe may be explained by the effect of a vaso-dilatation on a white stripe, and the red appearance of the throat-fan is no doubt in part due to blood, as well as to granules of red pigment in the subcutaneous connective tissue, which shows through the spaces between the scales.

On the Mechanism of the Color Changes

The essential structures present for the production of the various color states are the epidermis, the yellow oil droplet layer, the leucophore layer, the melanophores, and, possibly, the zanthophores and the cutaneous blood supply.

The skin of the scale is made up of four superimposed, inverted, hollow, cup-like layers, the outer being the epidermis. Next to this is the oil droplet layer, then the leucophore layer, and lastly, the connective tissue layer which, however, supports the integrity of the whole.

The first and last named layers are continuous with those of the neighboring scales, but the second and third are limited to the scale.

The epidermis is a transparent layer which acts largely as a protecting and supporting structure and, through interference phenomena, acts slightly, if at all, as a factor in the color states.

The second or yellow oil droplet layer presents a thin transparent yellow medium which is extremely important in the production of many of the color states. In and superficial to it lie the fine terminals of the branches of the melanophores. The large zanthophores also lie in it and extend inward into the next layer. The oil droplets give a strong, bright color by transmitted light, but seem to reflect but little light (Fig. 10 A and B). It seems to act more as a filter than as a reflector. White light reflected from

the underlying layer, when passing through this yellow medium, must be so acted upon as to give the yellow.

The leucophore layer, lying just internal to the oil droplet layer, acts essentially as a reflecting layer. It reflects a large proportion of the light which falls upon it, but it also screens the light to a great extent from the underlying brown melanophores so that pigment granules, when only in the bodies of the melanophores, exert but little influence on the color states of the skin. On the other hand, however, if the primary branches of the melanophores, which pierce this layer, are filled with pigment, the light which falls on it is reflected as blue light (Fig. 10 B). Further, cell bodies of the melanophores, lying internal to the leucophore layer, appear blue by reflected light in the scales of the ventral surface of the body in which the yellow oil droplet layer is very scant and in places absent (Fig. 7 B). Evidently then, the leucophore layer in part reflects all the rays of white light and also absorbs all but the blue rays from the light passing through it and reflected from the brown pigment within and internal to it. Traversing this leucophore layer are the large branches of the melanophores, connective tissue, and finer blood vessels. Partly imbedded in the lower stratum and beneath it are the melanophores. Fig. 17 is an attempt to show in perspective the various layers and their relation to one another.

The only layer that remains fixed and present in all scales and not subject to variations is the leucophore layer. All the other elements may be either absent, increased, decreased, or subject to marked variations. All of these other elements function in conjunction with the leucophore layer and either by allowing it to be unobscured, partially obscured, or by entirely shutting it off from the light, produce the color phenomena. The appearance of white and pale blue, as found on the ventral aspect of the body or along the mid-dorsal stripe, may be explained as due to the oil droplet layer being either absent or that it has been forced to the edges of the scale. A purely white scale must mean that the melanophores are either absent or greatly diminished in number, and very pale blue scales, that their pigment granules must have migrated entirely into the bodies of the cells. This allows the leucophore layer to act alone as a reflecting layer without the influence of any other element. In addition, the stratum corneum of the scales of the ventral surface is slightly thicker than in other regions, and this greater thickness, with the markedly developed

keel of the scale found here, no doubt results in more light being reflected from the outer surface of the scale and thus a whiter appearance. It seems probable that by a vaso-dilatation of the superficial capillaries a pink color may be imparted to the white scales. Further, in addition to the blood capillaries, red pigment is manifestly present in the subcutaneous connective tissue of the throat-fan.

If, in the white scales, melanophores are present and send out pigment into the primary and larger branches, the light, which is now acted upon by the leucophore layer, is returned as blue. Decidedly blue scales are rare except in isolated scales on the lateral aspect of the body. Along the mid-dorsal stripe and on the ventral aspect, melanophores are too few in number to influence the color beyond a pale blue. I injected brown pigment (potassium bichromate solution) into the skin of the belly, and a blue color was readily produced. Higgins' brown ink furnishes the same result in the same way.

The yellow or orange appearance may be readily explained by the presence of the yellow oil droplet layer through which light from the leucophore layer must be transmitted. The melanophores, in the case of the yellow skin, must contain the pigment in their bodies, and the branches must be free of pigment. The degree of yellow color depends on the amount of oil droplets, the straw-yellow color being associated with a lesser amount than the deep yellow. Pale yellow is often present on the ventral aspect of some lizards due to the presence of a small amount of this substance.

The emerald green is brought about by the migration of pigment into the primary and larger branches of the melanophores. Now the light which is reflected from the leucophore layer, due to the presence of pigment granules, is blue, and this blue, in passing through the yellow oil droplet layer, mixes with yellow rays given by this layer and appears at the surface as green. By further distal migration of the pigment granules, light from the leucophore layer assumes a deeper blue which in turn produces the bluish-green color of the skin.

By a still more distal migration of the pigment a muddy, greenish gray appears which, as the migration proceeds, becomes brownish gray, then light brown and, lastly, a deep mahogany brown is produced, which indicates that distal migration has proceeded till the granules have accumulated immediately beneath

the epidermis sufficiently to block the action of both the yellow oil droplets and the leucophore layer. The pigment granules now act entirely alone and produce the brown state (Figs. 12 and 13).

Whether the yellow oil droplet layer can be dispersed under varying stimuli in those scales where it normally exists, that is, whether it is possible for a lateral green scale to assume the white or bluish state in a short space of time, is difficult to say. If, as is held by Keller for the chameleon, the zanthophores possess the power of dilating and can take up all the space held previously by the oil droplet layer and thus displace the latter to the edges of the scale, it would at least be possible for a fairly rapid change to occur from green to white. Pouchet, however, believes the zanthophores of the chameleon to be of yellow color and if this be so, Keller's explanation would not be valid. The zanthophores of Anolis appear transparent in all the conditions under which I could observe them. They seem to be absent in the skin of the ventral surface of the body. However, my observations are by far too meager for me to draw any definite conclusions. It is true that the zanthophores seem greatly increased in the white scales of the mid-dorsal stripe and that they form a transparent fairly thick layer between the epidermis and the leucophore layer.

The objections to Keller's views are that if the zanthophores are able to disperse the oil droplet layer by dilating, they would probably also disturb the arrangement of the terminal branches of the melanophores, which we know does not take place. One would also conclude that these cells must be under the control of the nervous system. No conclusions can be reached without observing the living animals for long periods of time and noting the changes of these white areas. Possibly the white areas are merely variations and are more or less permanent. Black or brick-red stripes may be also variations in the distally migrated pigment.

The following table presents in a concise manner the mechanism involved in the various color states. Keller's theory in regard to the behavior of the zanthophores is included as a possibility, since their attributed function becomes necessary to explain white and blue changes in certain cutaneous areas, if these occur with any degree of rapidity.

TABLE 3

COLOR STATE	Oil Droplet Layer	Zantho-phore	Leuco-phore	Melano-phore	
White............	absent or dispersed	⊕ or absent	▭	●	
Blue.............	absent or dispersed	⊕ or absent	▭	● 1.	
Pink.............	absent or dispersed	⊕ or absent	▭	●	vaso-dilatation
Straw yellow......	partially dispersed	⊕ 2.	▭	●	
Golden yellow.....	▭	⊙ or absent	▭	●	
Emerald green....	▭	⊙ or absent	▭	● 1.	
Bluish green......	⊏	⊙ or absent	▭	● 2.	
Grayish green.....	▬ 1.	⊙ or absent	▬ 1.	● 3.	
Brownish green....	▬ 2.	⊙ or absent	▬ 2.	● 4.	
Light brown......	▬ 3.	⊙ or absent	▬ 3.	● 5.	
Mahogany brown..	▬	⊙ or absent	▬	○	brown pigment granules
Brick-red.........	▬	⊙ or absent	▬	○	brick-red pigment granules
Black............	▬	⊙ or absent	▬	○	black pigment granules

▭ unobstructed, ▬ partially obscured, ▬ obscured, ⊕ dilatation of zanthophore, ⊙ contraction of zanthophore, ○ maximum distal migration of pigment, ● partial distal migration of pigment, ● maximum proximal migration of pigment. No. 1-5 indicate comparative degrees of either obscuration or migration.

For the final solution of this problem of the color changes in Anolis, three methods of attack must be carried on and one must not lose sight of any one of them: Carefully controlled physiological experiments, histological studies of the skin, and careful

observations over long periods of time of the habits and color states of these lizards in their natural environment. The first method of attack is always open to criticism so long as the experiments are not carefully controlled; for instance in none of the experiments performed by either Parker and Starratt or Carlton were the factors of varying external stimuli taken into consideration.

Lizards kept for long periods in confinement may give one set of results but one is not justified in drawing any general conclusions as to the behavior of all lizards.

I wish to thank Doctor Hardesty and Doctor Garey for their helpful suggestions.

Summary

1. In its color changes, *Anolis carolinensis* shows a greater variety of colors than has been usually described for this animal. It may at times take on other colors than the emerald green, mahogany brown, and the variations intermediate between these. The variations, though apparently less frequent, correspond fairly closely with the variations described for *Chamæleon vulgaris*.

2. The color changes, in addition to general variations in *Anolis carolinensis*, as observed in its natural environment especially, seem to be induced by variations in external stimuli. Rhythmic changes of color may be observed with the animal in the same position with unchanged temperature and light, and emotional states interpreted as fear, sexual excitement, and anger (preliminary to and during combat) seem to more actively bring about color changes than temperature and light. Color changes in sympathy with environment (protective coloration) seem probable.

3. In structure, the skin of Anolis resembles that described by other investigators for *Chamæleon vulgaris*, except no "Negative Relief Schicht" could be distinguished in the stratum corneum of the epidermis, and no cells corresponding exactly to the erythrophores of Pouchet could be determined. Also the oil droplet layer described here for Anolis is not the same as the ochrophore layer described by Keller for Chamæleon.

4. The observations of Carlton that the processes of the melanophores in Anolis are fixed or non-amœboid and that migration of the pigment granules occurs within them, is hereby confirmed. In this the melanophores are similar to those described for

Chamæleon, *Fundulus heteroclitus*, *Rana temporaria*, and other color-changing animals.

5. The color changes in Anolis depend upon the reciprocal physical action of four layers of the skin: the epidermis, the yellow oil droplet layer, the leucophore layer and the melanophores. The physical characters making possible light interference and absorption, and the mixing of transmitted and reflected rays, modified by the migration of pigment to different positions in these layers, result in the varieties of color apparent at the surface of the skin at different times and on different localities of the body. The red coloration of the throat-fan is due to a rich capillary plexus and to the presence of a red coloring matter in the deeper layers. The effect of vaso-dilatation is also apparent in the pink stripe noted occasionally along the mid-dorsal line.

6. The oil droplet layer and the leucophore layer in general remain fixed and the various color states depend on the migration of the pigment granules in the fixed processes of the melanophores. Maximal proximal migration of the pigment is associated with yellow, while maximal distal migration produces dark mahogany brown. In the emerald green state the pigment lies in the primary and larger branches of the melanophores. Further distal migration is associated with bluish-green or slaty-gray color states depending on the degree.

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Description of Plates

Plate 7, Figs. 1-5

Camera-lucida outlines of scales of various parts of the body.

Plate 8, Fig. 6

(A). External surface of the skin of the lateral aspect under low power by transmitted light, showing yellow scales and indistinct melanophores (M).

(B). The same as above by reflected light showing the green scales with areas of brown pigmentation.

(C). Internal surface of the same skin by reflected light showing the blue scales with distinct dark melanophores (M).

Plate 8, Fig. 7

(A). External surface of the skin of the ventral aspect under low power by transmitted light showing the pale straw-colored scales with their indistinct melanophores (M).

(B). the same as above by reflected light showing the white scales with indistinct blue melanophores (M).

(C). Internal surface of the same by transmitted light showing the straw-colored scales with their distinct melanophores.

Plate 7, Fig. 8

Vertical section of a portion of the ventral scale (oil immersion) showing the stratum corneum (st. corn.), stratum germinativum (st. germ.), the leucophore layer (leuc.), a single melanophore (melan.), and the connective tissue (conn. tiss.).

Plate 7, Fig. 9

Scraping of the stratum corneum under oil immersion showing a group of squamous cells with their stippled appearance.

Plate 9, Fig. 10 (High Dry Power)

(A). Vertical section of a lateral scale in the green state by transmitted light, freshly hardened with twenty per cent formalin and unstained. This shows the transparent epidermis, the underlying layer of yellow oil droplets (O), the layer of leucophores (L), the melanophores with their numerous branches (M), and the underlying layer of connective tissue (C).

(B). The same by reflected light showing the bluish-white leucophore layer (L) and the black melanophores (M). The latter appear blue when lying beneath the former. The yellow oil droplet layer scarcely reflects any light.

PLATE 9, FIG. 11 (Oil immersion)

Vertical section of a lateral scale in the green state, stained with haemotoxylin and eosin showing the various layers of the epidermis and corium. Small amounts of pigment appear in the terminal branches of the melanophores but the mass appears in the cell bodies.

PLATE 9, FIG. 12 (Oil immersion)

Vertical section of a lateral scale in the brown state stained with haemotoxylin and eosin showing the pigment lying just beneath the epidermis.

PLATE 9, FIG. 13 (Oil immersion)

Vertical section of a dorso-lateral scale in the brown state stained with haemotoxylin and eosin showing the pigment cells (P) and a blood vessel, lying just beneath the connective tissue layer, sending a branch through all the layers and which ends just beneath the epidermis. The leucocytes are evident.

PLATE 9, FIG. 14 (Oil immersion)

Tangential section of a lateral scale in the brown state showing the pigment in the terminal branches of the melanophores (T), the pigment just beneath the epidermis (E), the leucophores with their bizarre outlines (L), the secondary branches of the melanophores piercing the openings between the melanophores (S), and the bodies of the melanophores with their primary branches (M).

PLATE 8, FIG. 15 (Oil immersion)

(A). Melanophores occasionally found showing a central migration of the pigment in the body of the cell, forming a rounded mass surrounded by a halo of clear cytoplasm.

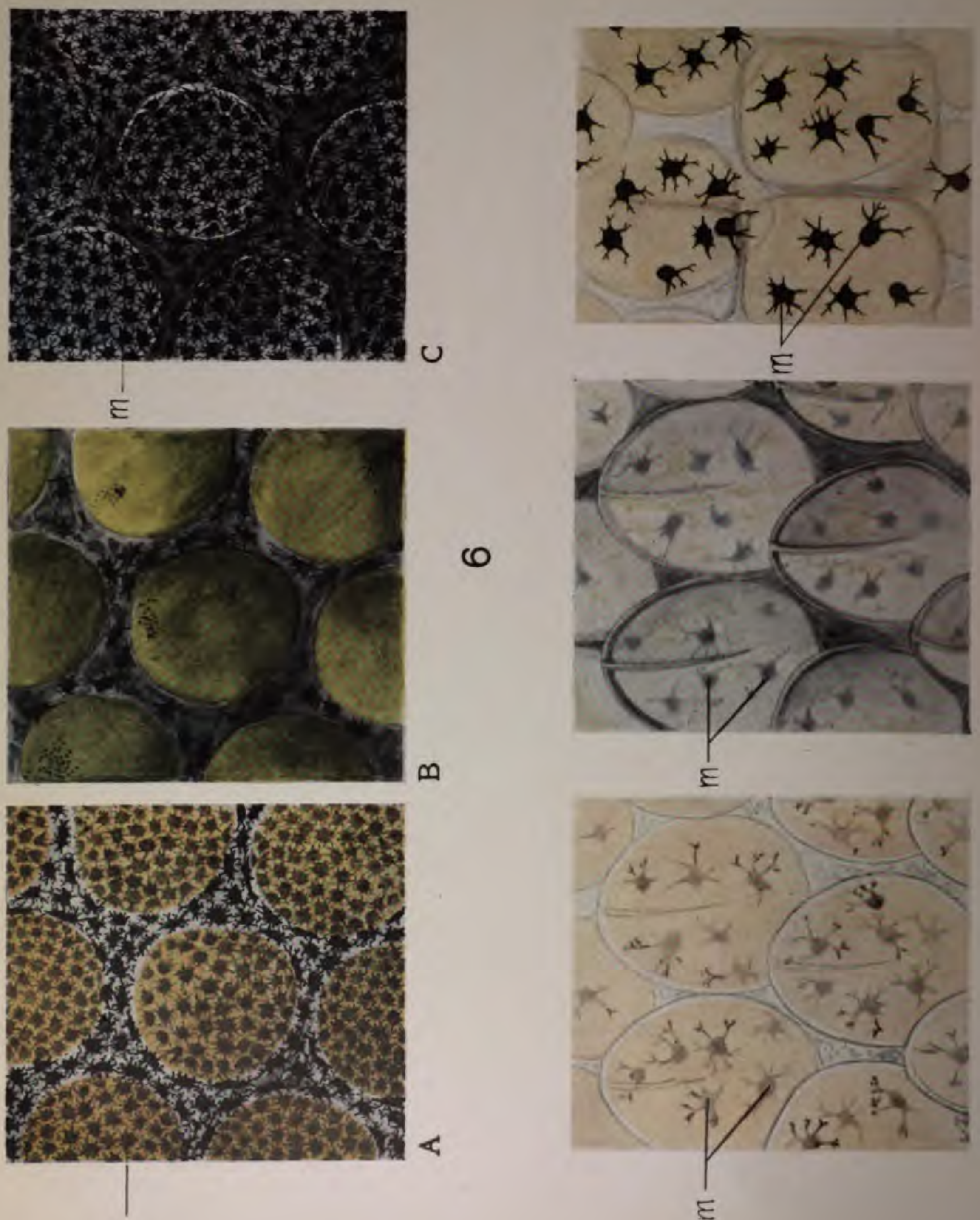
(B). Melanophores frequently found showing an almost complete proximal migration of the pigment. Practically no pigment exists even in the primary branches. The nuclei are evident.

PLATE 9, FIG. 16 (Oil immersion)

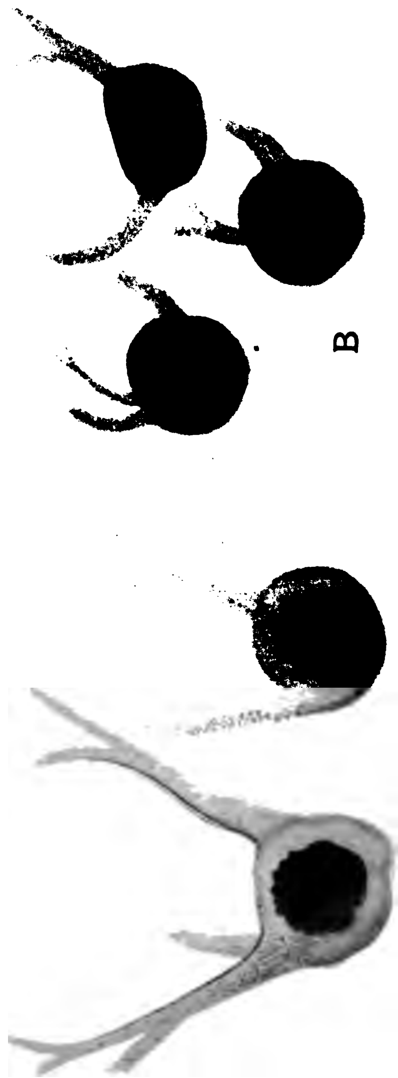
Pigment cell seen from above. These cells are found in the spaces between the scale and throughout the entire body. In vertical section these cells appear flat.

PLATE 7, FIG. 17

Reconstruction of the skin of *Anolis carolinensis* showing the essential elements necessary for the production of the color states, namely, the epidermis, yellow oil droplet layer, zanthophores, leucophores, and melanophores.



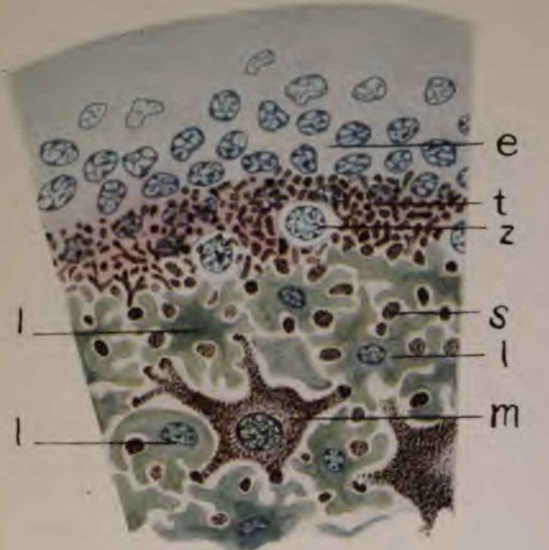
6



15

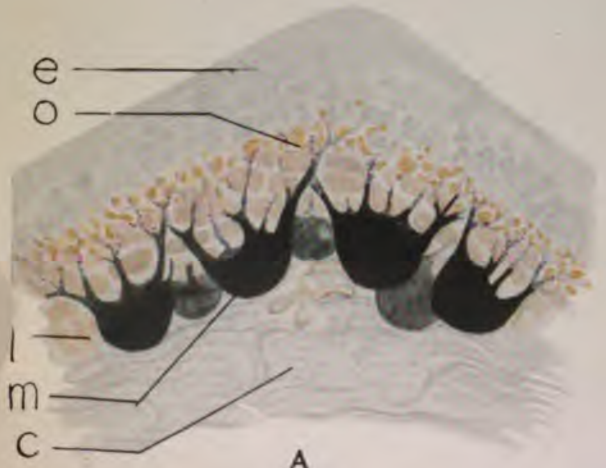
A

B



14

16



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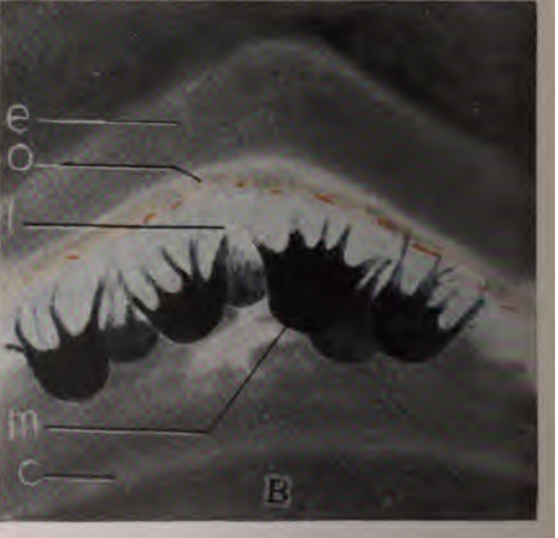
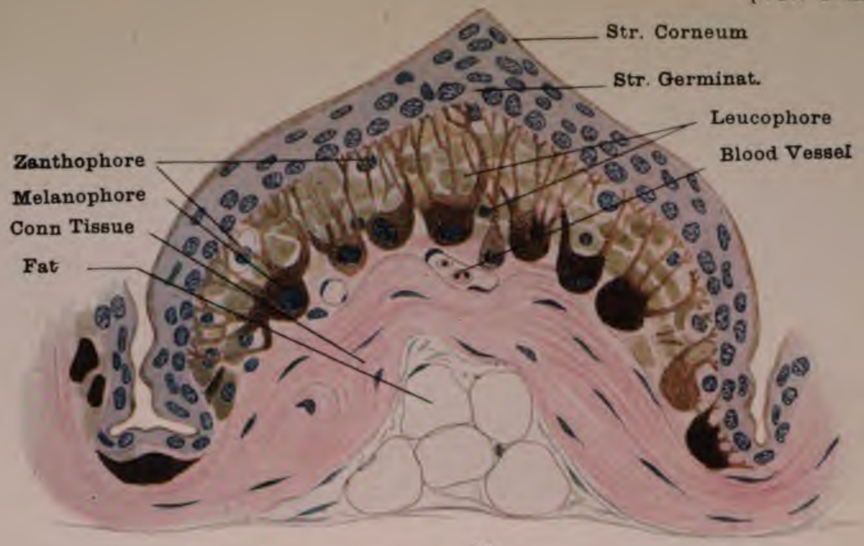


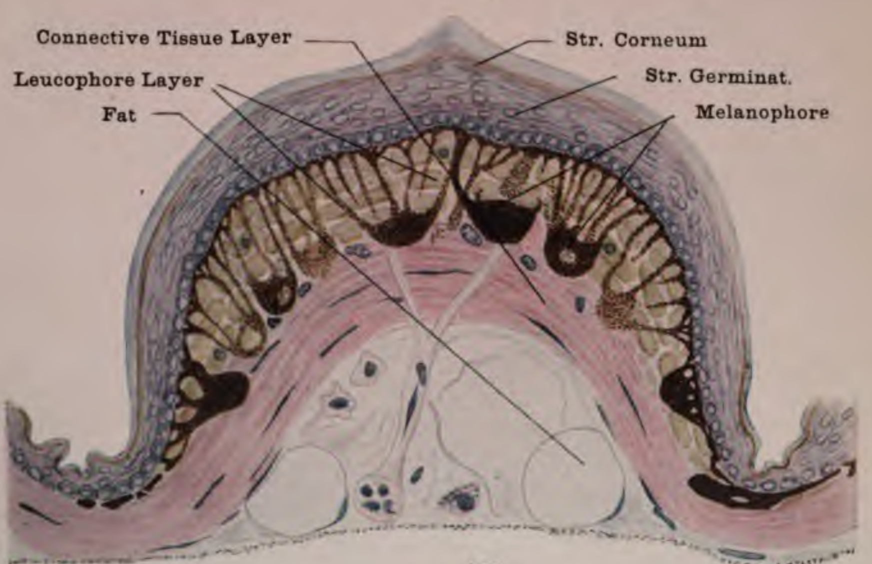
B

10



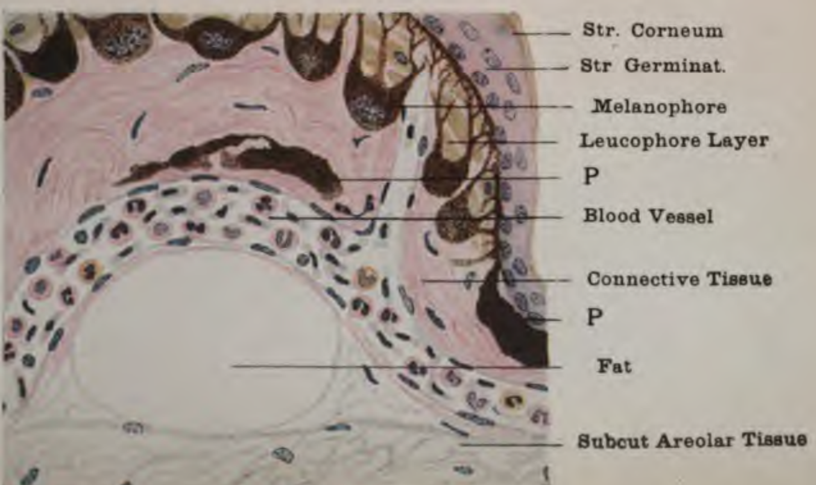
Str. Corneum
Str. Germinat.
Leucophore
Blood Vessel
Zanthophore
Melanophore
Conn Tissue
Fat

11



Connective Tissue Layer
Str. Corneum
Leucophore Layer
Str. Germinat.
Fat
Melanophore

12



Str. Corneum
Str Germinat.
Melanophore
Leucophore Layer
P
Blood Vessel
Connective Tissue
P
Fat
Subcut Areolar Tissue

13

PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

FOURTH SERIES

VOL. X, NOS. 11 AND 12, pp. 119-163 JULY 2, 1921

XI

Report of the President of the Academy for the Year 1920

BY

C. E. GRUNSKY

President of the Academy

XII

Report of the Director of the Museum for the Year 1920

BY

BARTON WARREN EVERMANN

Director of the Museum

SAN FRANCISCO

PUBLISHED BY THE ACADEMY

1921

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OF THE

CALIFORNIA ACADEMY OF SCIENCES

FOURTH SERIES

VOL. X, Nos. 11 AND 12, pp. 119–163 JULY 2, 1921

XI

REPORT OF THE PRESIDENT OF THE ACADEMY FOR THE YEAR 1920

By C. E. GRUNSKY
President of the Academy

In Academy affairs the year 1920 may be classed as relatively uneventful. Nevertheless some progress has been made.

The membership campaign under the leadership of Mr. M. Hall McAllister has continued successful. The number of members has increased from 550 to 927. There were 403 new members admitted while the loss of members was 20 by death, 5 by resignation, and 1 dropped for arrearages.

The present membership is made up of:

Patrons	12
Honorary Members	30
Life Members	82
Fellows	20
Members	783

The Academy carries on its list of patrons the following names:

Living

Mr. William B. Bourn
Mr. William H. Crocker
Mr. Peter F. Dunne
Mr. Herbert Fleishhacker
Mr. Joseph D. Grant
Mr. A. Kingsley Macomber
Mr. John W. Mailliard
Mr. Joseph Mailliard
Mr. M. Hall McAllister
Mr. Ogden Mills
Mr. Alexander F. Morrison
Mr. William C. Van Antwerp

Deceased

Mr. William Alvord
Mr. Charles Crocker
Mr. John W. Hendrie
Mrs. Charlotte Hosmer
Mr. James Lick
Mr. Ignatz Steinhart

Those who were called by death are as follows:

Mrs. Mary K. Brandegee	Life	April 3, 1920
Dr. John A. Brashear	Honorary	April 9, 1920
Dr. Frank S. Daggett	Member	April 5, 1920
Mr. I. W. Hellman	Member	April 9, 1920
Mrs. Charlotte Hosmer	Patron	November 30, 1920
Mr. G. Earle Kelly	Member	December 15, 1920
Mr. Curtis H. Lindley	Member	November 20, 1920
Mr. Bruce Martin	Member	1920
Mr. W. W. Montague	Life	September 28, 1920
Mr. Percy T. Morgan	Member	April 16, 1920
Mr. Charles P. Punchard	Member	November, 1920
Dr. Pier Andrea Saccardo	Honorary	February 12, 1920
Mr. Leon Sloss	Member	May 5, 1920
Mr. L. E. Smith	Life	October 12, 1920
Prof. Dr. H. zu Solms-Laubach	Honorary	1920
Dr. Franz Steindachner	Honorary	December 10, 1919
Mr. Sam B. Stoy	Member	August 18, 1920
Mr. Clement Tobin	Member	April 3, 1920
Dr. Ramsay H. Traquair	Honorary	November 22, 1912
Mr. Carlos Troyer	Life	July 26, 1920
Mr. Raphael Weill	Life	December 9, 1920

The Academy has published during 1920 the following papers in continuation of the Fourth Series of the Proceedings:

Vol. II, Part II, No. XVII, pp. 311-345
DERMAPTERA AND ORTHOPTERA,
by Morgan Hebard.

Vol. IX, No. XIII, pp. 331-356
NEW HEMIPTEROUS INSECTS OF THE GENERA ARADUS, PHYTOCORIS AND CAMPTOBROCHYS,
by Edward P. Van Duzee.

Vol. IX, No. XIV, pp. 357-365
REPORT OF THE PRESIDENT OF THE ACADEMY FOR THE YEAR 1919,
by C. E. Grunsky.

Vol. IX, No. XV, pp. 367-396
REPORT OF THE DIRECTOR OF THE MUSEUM FOR THE YEAR 1919,
by Barton Warren Evermann.

Vol. X, No. I, pp. 1-27
A FURTHER STUDY OF VARIATION IN THE GOPHER-SNAKES OF WESTERN NORTH AMERICA,
by John Van Denburgh.

Vol. X, No. II, pp. 29-30
DESCRIPTION OF A NEW SPECIES OF RATTLESNAKE (*Crotalus lucasensis*) FROM LOWER CALIFORNIA,
by John Van Denburgh.

Vol. X, No. III, pp. 31-32
DESCRIPTION OF A NEW SUBSPECIES OF BOA (*Charina bottæ utahensis*) FROM UTAH,
by John Van Denburgh.

Vol. X. No. IV, pp. 33-34
DESCRIPTION OF A NEW LIZARD (*Dipsosaurus dorsalis lucasensis*) FROM LOWER CALIFORNIA,
by John Van Denburgh.

Vol. X, No. V, pp. 35-46
UNDESCRIBED TIPULIDÆ (DIPTERA) FROM WESTERN NORTH AMERICA,
by Charles P. Alexander.
Vol. X, No. VI, pp. 47-49
THREE NEW SPECIES OF DOLICHOPODIDÆ (DIPTERA) FROM CALIFORNIA AND NEVADA,
by M. C. Van Duzee.
Vol. X, No. VII, pp. 51-52
TWO NEW SPECIES OF SYRPHIDÆ (DIPTERA),
by A. L. Lovett.
Vol. X, No. VIII, pp. 53-70
NOTES ON SOME UNDESCRIBED CALIFORNIAN HELICES,
by S. Stillman Berry.
Vol. X, No. IX, pp. 71-75
A NEW GENUS AND SPECIES OF GRASSHOPPER FROM CALIFORNIA,
by Morgan Hebard.

During the year 1920, 11 free lectures have been delivered at the stated meetings of the Academy, as follows:

JANUARY 7. "The Vegetation of New Zealand."
Mr. A. H. Cockayne, Government Biologist of New Zealand.

MARCH 3. "American Aquariums."
Dr. Barton Warren Evermann, Director of the Museum, California Academy of Sciences.

APRIL 7. "A Commodity Unit to Supplement Money as a Standard of Value."
Dr. C. E. Grunsky, President, California Academy of Sciences.

MAY 5. "Some Bird Observations on the University Campus."
Mr. Tracy I. Storer, Field Naturalist, Museum of Vertebrate Zoology, University of California.

JUNE 2. "The Work of the Audubon Society."
Mr. C. B. Lastreto, Organizer and Ex-President of the Audubon Association of the Pacific.

JULY 7. "The Birds and Mammals of the Stikine Region, British Columbia."
Mr. H. S. Swarth, Curator of Birds, Museum of Vertebrate Zoology, University of California.

AUGUST 4. "The Botanical Features of Mount Tamalpais."
Miss Alice Eastwood, Curator of Botany, California Academy of Sciences.

SEPTEMBER 1. "Injurious Insects."
Mr. E. O. Essig, Assistant Professor of Entomology, University of California.

OCTOBER 6. "Hunting Grizzlies with Bow and Arrow."
Dr. Saxton Pope, Assistant Clinical Professor of Surgery, University of California.

NOVEMBER 3. "The Pan-Pacific Scientific Congress and the Hawaiian Islands."
Dr. Barton Warren Evermann, Director of the Museum, California Academy of Sciences.

DECEMBER 1. "Birds, Fur Seals, Foxes and Other Animals of the Pribilof Islands, Alaska."
Dr. G. Dallas Hanna, Curator of Invertebrate Paleontology, California Academy of Sciences.

The Sunday afternoon lectures delivered in the Museum building during 1920 have included the following:

JANUARY 4. California's Fur-Bearers.
Dr. H. C. Bryant, in charge Education and Publicity, California Fish and Game Commission.

JANUARY 11. Life History of the Little Smelt or Grunion.
Mr. W. F. Thompson, in charge State Fisheries Laboratory, California Fish and Game Commission.

JANUARY 18. The Game Warden and His Work.
Mr. J. S. Hunter, Assistant Executive Officer, California Fish and Game Commission.

JANUARY 25. The Commercial Fisheries of California.
Mr. N. B. Scofield, in charge Commercial Fisheries Department, California Fish and Game Commission.

FEBRUARY 1. The Ocean as an Abode of Life.
Dr. W. K. Fisher, Director, Hopkins Marine Station of Stanford University.

FEBRUARY 8. The Steinhart Aquarium.
Dr. Barton Warren Evermann, Director of the Museum, California Academy of Sciences.

FEBRUARY 15. The Ocean Meadows, or the Microscopic Life of the Open Sea.
Dr. C. A. Kofoid, Professor of Zoology, University of California.

FEBRUARY 22. Fishes of the California Coast.
Prof. E. C. Starks, Assistant Professor of Zoology, Stanford University.

FEBRUARY 29. Marine Mammals.
Dr. Harold Heath, Professor of Zoology, Stanford University.

MARCH 7. Alaska and the Fur Seals.
Dr. Barton Warren Evermann, Director of the Museum, California Academy of Sciences.

MARCH 14. Life of the Deep Sea.
Prof. J. O. Snyder, Associate Professor of Zoology, Stanford University.

MARCH 21. Oceans of the Past.
Dr. J. P. Smith, Professor of Paleontology, Stanford University.

MARCH 28. Systematic and Economic Phases of California Marine Algæ.
Dr. N. L. Gardner, Assistant Professor of Botany, University of California.

APRIL 4. Life Between Tides.
Dr. W. K. Fisher, Director, Hopkins Marine Station of Stanford University.

APRIL 11. Plant Migrations.
Dr. Douglas H. Campbell, Professor of Botany, Stanford University.

APRIL 18. The California Big Trees and History.
Dr. L. L. Burlingame, Associate Professor of Botany, Stanford University.

APRIL 25. Some Plant Diseases.
Prof. J. I. W. McMurphy, Assistant Professor of Botany, Stanford University.

MAY 2. The Trees of California.
Dr. Leroy Abrams, Associate Professor of Botany, Stanford Universitv.

MAY 9. Plants and a Hungry World.
Dr. George J. Peirce, Professor of Botany and Plant Physiology, Stanford University.

SEPTEMBER 12. The Origin of the Polynesian People.
Dr. W. E. Safford, Bureau of Plant Industry, Department of Agriculture, Washington, D. C.

SEPTEMBER 19. A Recent Visit to the Hawaiian Islands.
Dr. Barton Warren Evermann, Director of the Museum, California Academy of Sciences.

SEPTEMBER 26. The Solar System.
Dr. W. W. Campbell, Director, Lick Observatory, Mount Hamilton, California.

OCTOBER 3. Comets.
Dr. A. O. Leuschner, Dean of the Graduate Division, University of California.

OCTOBER 10. The Binary Stars.
Dr. R. G. Aitken, Astronomer, Lick Observatory, Mount Hamilton, California.

OCTOBER 17. The Nebulæ.
Dr. J. H. Moore, Astronomer, Lick Observatory, Mount Hamilton, California.

OCTOBER 24. What We Owe to Animal Experimentation.
Dr. S. J. Holmes, Professor of Zoology, University of California.

OCTOBER 31. Early Ideas of the Earth.
Prof. Earle G. Linsley, Professor of Geology and Astronomy, Mills College.

NOVEMBER 7. The Spectroscope—A Key to Celestial and Atomic Mysteries.
Dr. E. P. Lewis, Professor of Physics, University of California.

NOVEMBER 14. Some Phases of Our Modern Conquest of the Air.
Dr. W. F. Durand, Professor of Mechanical Engineering, Stanford University.

NOVEMBER 21. The Future of the Tropics as a Factor in World Development.
Dr. R. S. Holway, Professor of Geography, University of California.

NOVEMBER 28. Cipher Messages from the Stars.
Dr. J. H. Moore, Astronomer, Lick Observatory, Mount Hamilton, California.

DECEMBER 5. Earthquakes on the Pacific Coast of North America.—I.
Dr. S. D. Townley, Professor of Applied Mathematics, Stanford University.

DECEMBER 12. Earthquakes on the Pacific Coast of North America.—II.
Dr. S. D. Townley, Professor of Applied Mathematics, Stanford University.

DECEMBER 19. The United States in Haiti and Santo Domingo.
Mr. M. E. Beall, Berkeley, California.

Ground has not yet been broken for the Steinhart Aquarium. This is not due to any lack of desire on the part of the Council and the Trustees to further its early construction. The trust which the Academy has accepted will be faithfully discharged. More than a year ago the bequest became available and the sum of $250,000 was paid to the

Academy. This sum was at once invested and interest has been accumulating. Dr. Evermann, accompanied by Civil Engineer T. Ronneberg, has made an inspection trip to all the notable aquariums in the United States in order that the Academy may have the advantage of the latest and best ideas on general arrangement, lighting and operation. The architect, Mr. Lewis P. Hobart, thereupon made a number of preliminary studies from which it presently became apparent that the funds at our disposal were not adequate to provide a building of the size, dignity and architectural finish which would be required if the aquarium is given the place of honor in the Academy's building scheme. It was found impracticable, in other words, to put the aquarium to the East of the unit in which our present exhibits and activities are housed, where it could be made, if funds permitted, an imposing central feature at the rear of an aquatic court. When this fact became apparent the architect did the next best thing. He so arranged a design that only a small portion of the exterior of the building would require finishing in stone. But even with this arrangement under which only a narrow front of the building would be architecturally ornamental, there has been difficulty in finding a site at once appropriate and acceptable to the Board of Park Commissioners. The matter of selecting a site and of suggesting a building suited to the site is now in the hands of a joint committee of the Park Commission and of the Academy.

It is regrettable that the funds placed by bequest at the disposal of the Academy are limited to an amount which will not give to San Francisco all that is desired in connection with a first class, fully equipped aquarium in which the marine life of the Pacific Ocean and the aquatic life of the streams which flow into the Pacific Ocean should be adequately represented. Even with extreme restriction of the exterior ornamentation of the aquarium building it will not be possible to provide more than about 50 tanks of moderate size. There will be no space provided in accomplishing this result for fishery and display exhibits, for research work, or for offices. The bare housing of the fish tanks, and of the machinery and appliances required to store, filter, aerate and cool or heat the water, is all that can be accomplished with the means at command.

Some thought has been given to combining with the aquarium an auditorium or otherwise bringing under the same roof space that may be used for other purposes, without in any sense detracting from the distinctiveness of the Steinhart Aquarium. Nothing along this line seems possible of accomplishment. The aquarium once established will always be the "Steinhart Aquarium." Enlargement or extension by other bequests or endowments is not likely so long as the features added by such bequests or endowments are not sufficiently distinctive to perpetuate the names of those whose generosity prompts their making. Nor does it seem likely that the City, which is the beneficiary, could be prevailed on in the near future to increase the initial fund. Nevertheless, before it is too late, this thought is thrown out. It would indeed be a gracious thing if the City which has authorized the Academy to accept the bequest and to take charge of the erection and operation of an aquarium in Golden Gate Park, would add a like amount. It would thereby make possible the erection of a dignified structure adequate for immediate needs and arranged for expansion to meet any future requirements.

The financial standing of the Academy will appear from the Treasurer's report. The endeavor of the Council and of the Trustees has been to do the utmost that could be done within our resources as well in the matter of adding to the material in the Academy's collections as in research work and the publication of results. What has been done along these lines will appear more fully from the report of Dr. Evermann, the Director of the Museum, and the reports of the curators of the various departments.

As you were advised a year ago our floating debt which had been incurred during the erection of the Museum building, had been wiped out in 1919. This year we note with satisfaction that our indebtedness on the Academy's Market Street property has been reduced by $10,000, from $300,000 to $290,000.

For a grizzly bear habitat group, as was noted in the President's last annual report, funds have been provided by Mr. Ogden Mills and the necessary specimens for the group have now been secured from the Yellowstone Park without

expense to the Academy, by Dr. Saxton Pope, assisted by Arthur Young and G. D. Pope. Permission was granted by the Park authorities to get four grizzly bear for this purpose. It is expected that before the close of this calendar year the group will be installed. It will fill the last available alcove and, thereafter, the need for more exhibit space will be felt more than ever.

The Academy is a growing institution, as yet but inadequately equipped to carry on the activities which should be its special concern. It should have more housing facilities for scientific and educational natural history material. It should be engaged in carrying natural history lessons into the school rooms of the city and it should have better facilities for popular lectures on scientific subjects. Despite the present inadequate facilities the weekly lectures (Sunday afternoons) have proved very successful. Their scope appears from the list submitted. They are attended to the limit of our small auditorium's seating capacity. I am sure that I voice the sentiments of all members and friends of the Academy who have attended any of these lectures, when I say that the kindness of those who have given the lectures, frequently at no little personal inconvenience, has been sincerely appreciated.

In the President's last annual report note was made of the fact that on appeal to the Supreme Court, the will of Mr. S. F. Thorn under which the Academy was bequeathed some land near Santa Cruz and other property, had been sustained. It was subsequently learned that this decision was not rendered by the Court *in banc*. Upon further hearing, the Court *in banc* reversed the earlier decision, finding that the will was not holographic because the single word "Cragthorn" had been inserted with a rubber stamp. The will was declared illegal and it now appears that the announcement of last year was at fault and that the Academy takes nothing under the will.

Among the notable acquisitions of the Academy during the year is the W. Otto Emerson collection of bird skins, some 5300 in number. Most of the birds represented in this collection, which has great scientific value, are from Alameda County. It has come to us through the generosity of W. H. Crocker and John W. Mailliard.

Private subscriptions by a number of friends of the Academy have made possible the purchase of the Albert Prager Herbarium, which contains many valuable plant specimens from various parts of the globe. Negotiations for the transfer of this herbarium from Leipzig, Germany, the home of Mr. Prager, to the Museum of the Academy, have been completed.

Your officers again commend the zeal and ability with which the curators of the Academy's departments have conducted their work, which goes so far in maintaining the standing of the Academy as a scientific institution of real worth. Your officers are appreciative too of the interest taken by the membership in the activities of the Academy, and are gratified to note how popular the museum has become as evidenced by the large number of visitors reported by the Director of the Museum.

The Academy stands ready to enlarge its usefulness. It can do so materially, however, only through outside help. As opportunity offers this fact should be made known to those who are so circumstanced that they can serve mankind by establishing endowments for useful purposes. They should know that the Academy is ready to serve.

XII

REPORT OF THE DIRECTOR OF THE MUSEUM FOR THE YEAR 1920

BY

BARTON WARREN EVERMANN
Director of the Museum

The annual report of the Director for the year 1919 was presented to the Academy at the annual meeting February 18, 1920. At that time all except one of the spaces for large habitat groups in the mammal and bird halls had been filled. The one remaining space has been reserved for a Grizzly Bear Group. The grizzly bear is now extinct in California. None of us will ever see a living example of that magnificent animal which figured so prominently in the early history of the State; it is said there is no really good specimen of the species in any museum in the world. It has therefore been decided to put in a habitat group of a closely related species (*Ursus imperator*) which occurs in the Yellowstone Park. Dr. Saxton Pope (a member of the Academy) of San Francisco, offered to secure the necessary animals, without expense to the Academy, if the necessary permit were secured. Application was made to the National Park Service for a permit for Dr. Pope to kill the necessary animals, the permit was obtained, and Dr. Pope secured the animals. The taxidermists have begun the preparation of the group which, it is believed, will be completed by September, 1921.

When Mr. Ogden Mills visited the Museum recently he was so pleased with what the Academy has already accomplished in habitat group installation that he generously gave his check to the Academy for $5000 to cover the cost of the proposed Grizzly Bear Group. It is very gratifying to know that this Museum is so appreciated and the Academy feels grateful to Mr. Mills for this expression of his appreciation.

Small Habitat Groups.—With the completion of the Grizzly Bear Group all the available spaces for large groups will have been utilized. There will remain only spaces for 24 small panel

groups—five in the bird hall and 19 in the mammal hall. It is hoped that all these may be completed within the next few years.

PERSONNEL

Only a few changes have taken place in the personnel of the Museum within the year. Mr. William Heim, who was employed as taxidermist, took indefinite leave August 16, 1920, on account of ill health. It is hoped he may be able to return at an early date. Mr. Francis G. Gilchrist, who was employed May 10, 1920, as assistant in the department of Ornithology and Mammalogy, resigned July 30 to re-enter the University of California. Harvey R. Scott was employed as assistant taxidermist from July 28 to August 20. Chase Littlejohn has been employed as assistant curator, department of Ornithology and Mammalogy, since September 13.

The employes of the Academy at this date are as follows: Dr. Barton Warren Evermann, Director and Executive Curator of the Museum, and Editor; W. W. Sargeant, Secretary to the Board of Trustees; Miss Susie Peers, Secretary to the Director; Joseph W. Hobson, Recording Secretary; Miss Alice Eastwood, curator, Department of Botany; Edward P. Van Duzee, curator, Department of Entomology, and assistant librarian; Dr. John Van Denburgh, curator, Department of Herpetology; Dr. Roy E. Dickerson, honorary curator, Department of Invertebrate Paleontology; Dr. G. Dallas Hanna, curator, Department of Invertebrate Paleontology; Dr. Walter K. Fisher, curator, Department of Invertebrate Zoology; Joseph Mailliard, curator, Department of Ornithology and Mammalogy; Joseph R. Slevin, assistant curator, Department of Herpetology; Chase Littlejohn, assistant curator, Department of Ornithology and Mammalogy; Mrs. Marian L. Campbell and Mrs. Kate E. Phelps, assistants, Department of Botany; Mrs. Helen Van Duzee, assistant, Department of Entomology and in the Library; Miss Mary E. McLellan, Library assistant; William Heim, assistant, Department of Exhibits (on leave); John I. Carlson, general assistant; Raymond Smith, general assistant; Georges Vorbe, Merle Israelsky, and William Barbat, temporary assistants, Department of Invertebrate Paleontology; William

C. Lewis, janitor; Fred Maag, carpenter and assistant janitor; George W. Edwards, assistant janitor; Frank W. Yale, night watchman; Mrs. Johanna E. Wilkens, janitress; Patrick J. O'Brien, day watch; Archie McCarte, night watch.

ACCESSIONS TO THE MUSEUM AND LIBRARY

Accessions to the Museum and the Library have been unusually numerous and valuable, as is shown by the detailed list in the appendix to this report (pp. 149-158).

VISITORS TO THE MUSEUM

In accordance with established policy, the Museum was open to the public every day in the year. The attendance by months for each of the years since the Museum was first opened to the public is shown in the following table:

Month—	1916	1917	1918	1919	1920
January	.....	23170	25260	17241	27013
February	.....	22058	23698	19586	23450
March	.....	31606	26810	27397	25419
April	.....	32175	23274	25994	32208
May	.....	26154	26391	28369	37107
June	.....	32123	29843	32248	36207
July	.....	37193	31420	48028	52492
August	.....	24619	31137	43730	53470
September	16448[1]	27866	29847	34007	42413
October	36933	20629	14743[2]	30463	33500
November	27718	21810	8531[2]	25246	19347
December	15002	21693	19588	21246	21340
Total	96101	321096	290542	351497	403566

A comparison of the number of visitors to the Museum of the California Academy of Sciences with those who visited the Smithsonian Institution and the National Museum at Washington in the year ending June 30, 1920, will prove very interesting. The visitors by months are given in the following table, which shows that the number visiting the Smithsonian Institution was only 21 per cent of those visiting the Academy Museum; the number visiting the Natural History Building of the National Museum was only 4.7 per cent. greater than that at the Academy, while that at the Arts and Industries Building of the National Museum was only 62 per cent of that at the Academy. These figures should be very gratifying to us.

[1] Attendance from September 22 to 30.
[2] Museum closed 29 days on account of the "flu."

NUMBER OF VISITORS BY MONTHS FOR THE YEAR ENDING JUNE 30, 1920

AT THE

MUSEUM OF THE CALIFORNIA ACADEMY OF SCIENCES
THE SMITHSONIAN INSTITUTION

AND

NATIONAL MUSEUM IN WASHINGTON, D. C.

Year and Month	California Academy of Sciences	Smithsonian Institution	United States National Museum	
			Arts and Industries Building	Natural History Building
1919				
July	52,492	7,812	24,755	33,631
August	53,470	9,594	29,501	45,392
September	42,013	9,690	29,697	44,974
October	33,500	7,245	21,401	36,906
November	19,347	5,875	18,971	38,420
December	21,340	4,992	13,149	23,751
1920				
January	27,013	4,264	11,491	22,914
February	23,450	3,439	10,168	21,740
March	25,419	6,371	15,815	32,204
April	32,208	8,121	23,207	38,954
May	37,107	9,978	27,556	46,089
June	36,207	8,632	25,271	38,009
Total	403,566	86,013	250,982	422,984

COOPERATION WITH SCHOOLS

The Museum continues to cooperate with the public and private schools. Teachers and school officials are coming to realize more and more clearly that the Museum can be of real service to the schools. The number of schools visiting the Museum increases each year. During the year 1920 there were schools from San Francisco, Berkeley, Oakland, Alameda, Piedmont and Richmond, and classes from San Jose, San Rafael, San Anselmo, San Mateo, and Stockton. Whenever possible, the Director or some one of the Museum staff accompanies the school through the Museum and explains briefly the general features of the installations, calling at-

tention to the educational value of the various exhibits, and then, when time permits, the class is taken into the lecture hall and shown moving pictures or stereopticon slides illustrative of some of the exhibits.

The visits by schools in the year have been as follows:

Schools of San Francisco	
Number of classes	280
Number of teachers with the classes	270
Number of pupils	19920
Schools outside of San Francisco	
Number of classes	26
Number of teachers with the classes	18
Number of pupils	444
Total number of classes	306
Total number of teachers	288
Total number of pupils	10364

THE PAN-PACIFIC SCIENTIFIC CONGRESS

Under the auspices of the Pan-Pacific Union, the First Pan-Pacific Scientific Congress met at Honolulu August 2 to 21. The Director of the Museum attended the Congress, as a member of the Pacific Explorations Committee of the National Research Council and representing also the California Academy of Sciences and the Pacific Division of the American Association for the Advancement of Science. He sailed from San Francisco July 28 and returned September 8. August 3 to September 1 were spent attending the sessions of the Congress and visiting places of interest on the islands of Oahu and Hawaii.

The number of delegates and others in attendance upon the sessions of the Congress was more than 100. There were present delegates from New Zealand, Australia, the Philippines, China, Japan, Canada, England, and the United States, many of those from the United States representing various scientific bureaus of the Government.

The papers and discussions at the sessions of the Congress covered many phases of the geology, meteorology, and natural history of the Pacific and its contained islands, and it was clearly shown that much of importance remains to be learned

regarding the hydrography, geology, and natural history of the Pacific.

At the close of the Congress the unanimous verdict was that the meeting had been a decided success, and that other meetings should be held every two or three years.

FIELD WORK OF THE MUSEUM STAFF

Within the year the Museum carried on a number of field investigations, as fully set forth in the reports of the curators.

MEETING OF THE PACIFIC DIVISION OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE AND ITS AFFILIATED SOCIETIES

The 1920 meeting of the Pacific Division was held at Seattle, June 17 to 19. All the sessions of the Association and of its affiliated societies were held in various halls of the University of Washington. The Academy membership was well represented, at least 25 of its members being present. The Director of the Museum was in attendance as vice-president and chairman of the executive committee of the Pacific Division, and Secretary W. W. Sargeant as secretary of the Pacific Division. The Academy was represented on the programs by the following members:

Mr. W. F. Thompson	Dr. E. L. Packard
Dr. Barton Warren Evermann	Dr. Chester Stock
Prof. John N. Cobb	Dr. Wm. E. Ritter
Mr. W. E. Allen	Prof. Tracy I. Storer
Mr. Willis H. Rich	Dr. E. P. Meinecke
Dr. John C. Merriam	Dr. W. F. Durand
Dr. E. P. Lewis	Dr. J. R. Slonaker
Dr. J. W. Moore	Miss Alice Eastwood
Dr. R. G. Aitken	Dr. D. T. MacDougal
Dr. Bruce L. Clark	

Several others were in attendance.

USE OF THE ACADEMY'S COLLECTIONS AND LIBRARY BY INVESTIGATORS AND STUDENTS

Students and investigators continue to avail themselves of the facilities offered by the Academy for study and research. The Library, with its more than 50,000 books and pamphlets

in the various departments of science, is in almost daily use by students. This has been especially true of geologists and paleontologists, who are interested in oil investigations and prospecting. The large research collections in the different departments have been consulted by a number of investigators. Mr. L. M. Loomis continues to avail himself of the Academy's collections and Library in his study of sea birds. Messrs. Joseph Grinnell, Harry S. Swarth, Tracy I. Storer, and J. Eugene Law, of the Museum of Vertebrate Zoology, have had occasion to consult our collections of birds, mammals and reptiles. Numerous entomologists of the west coast make frequent use of the rapidly growing collections in that department, and the botanists of the coast find it to their interest to consult the herbarium.

The Boy Scouts, under Scout Master Harold E. Hanson, have continued the Friday night meetings at the Museum throughout the year. The Academy is glad to cooperate in this way.

PUBLICATIONS BY THE MUSEUM STAFF

The curators and other members of the Museum staff have continued active in research work and in their contributions to the scientific literature of their respective fields of investigation, as evidenced by the following list of titles of papers published by them in 1919-1920:

Evermann, Barton Warren

1. Nesting of the Wilson Snipe in California. <The Condor, Vol. XXI, No. 3, May-June (June 6), 1919, p. 121.
2. Large Set of Eggs of the Canada Goose. <The Condor, Vol. XXI, No. 3, May-June (June 6), 1919, p. 126.
3. California Trout. <California Fish and Game, Vol. V, No. 3, July, 1919, pp. 105-135, 4 colored plates, text-figures 36-46. (With Harold C. Bryant.)
4. The Northern Fur-Seal Problem as a Type of Many Problems of Marine Zoology. <The Scientific Monthly, Vol. IX, No. 3, September, 1919, pp. 263-282, 4 plates, 6 text-figures.
5. A Colony of Tricolor Blackbirds. <The Gull, Vol. I, No. 9, pp. 2-3, September, 1919.
6. The Steinhart Aquarium, San Francisco. <Aquatic Life, August, 1919, pp. 159-160, 1 plate.
7. Note on the Basking Shark. <Copeia, No. 74, October 15, 1919, pp. 77-78.

8. A Water-Fowl Habitat Group. <Museum Work, Vol. II, No. 2, November, 1919, p. 35, 1 plate.
9. Museum Exhibits of Real Value. <Outers' Recreation, Vol. LXI, No. 6, December, 1919, p. 435, 1 text-figure.
10. The Northern Fur-Seal Problem as a Type of Many Problems of Marine Zoology. <Bulletin No. 9 of the Scripps Institution for Biological Research of the University of California, pp. 13-26, December 15, 1919. (Differs somewhat from No. 4.)
11. Scientific and Economic Problems of the Mammals and Birds of the North Pacific. <Bulletin No. 9 of the Scripps Institution for Biological Research of the University of California, pp. 27-34, December 15, 1919.
12. Plans for the Steinhart Aquarium. <Pacific Fisherman, Vol. XVII, No. 12, December, 1919, p. 63, 1 text-figure.
13. A Mountain Sheep Habitat Group. <Forest and Stream, Vol. XC, No. 1, January, 1920, p. 32, 1 text-figure.
14. Birds' Nests in the Music Concourse, Golden Gate Park. <The Gull, Vol. II, No. 1, January, 1920, p. 3-4.
15. The Steinhart Aquarium, California. <The American Angler, Vol. V, No. 1, May, 1920, pp. 19-20, 1 text-figure.
16. Lake Maxinkuckee: A Physical and Biological Survey. The Department of Conservation, State of Indiana, Publication No. 7, Volume I, pp. 1-660, 9 halftone plates, 38 colored plates, 24 text-figures, 1 map; Volume II, pp. 1-512, 1920 (September) (with Howard Walton Clark).

Hanna, G. Dallas

1. The Introduction of *Acanthinula harpa* and *Circinaria vancouverensis* on St. Paul Island, Alaska. <The Nautilus, Vol. XXXIII, No. 4, p. 143, April, 1919.
2. Fossil Mollusks from the John Day Basin in Oregon. <University of Oregon Publications, Vol. I, No. 6, pp. 1-8, pl. I, August, 1920.
3. Report of the Department of Invertebrate Paleontology for 1919. <Proceedings of the California Academy of Science, Ser. 4, Vol. IX, Nos. 14-15, pp. 387-389, August, 1920.
4. New and Interesting Records of Pribilof Island Birds. <The Condor, Vol. XXII, No. 5, pp. 173-175, Sept.-Oct. (September 24), 1920.
5. Birds of the Alaska Fur Seal Islands. <The Gull, Vol. II, No. 12, December, 1920.
6. Census of Alaska Fur Seals in 1919. <Rept. U. S. Commissioner of Fisheries for 1919(1920). Bureau of Fisheries Document No. 891.

Mailliard, Joseph

1. **Notes from the Feather River Country and Sierra Valley, California. <The Condor, Vol. XXI, p. 74, March 25, 1919.**

Van Duzee, Edward P.

1. Report of the Canadian Arctic Expedition, Vol. III, Insects, F, Hemiptera, Ottawa, 1919, 5 pages.
2. New Hemipterous Insects of the Genera Aradus, Phytocoris, and Camtobrochys. <Proc. Calif. Acad. Sci., Fourth Ser., Vol. IX, No. 13, pp. 331-356, February 5, 1920.

DEPARTMENT REPORTS

The curators and their assistants have been unusually active and efficient during the year in building up and caring for the collections in their respective departments, as is fully set forth in their respective reports.

DEPARTMENT OF BOTANY

The herbarium of the California Academy of Sciences now numbers 67,789 mounted specimens representing 18,825 species, an increase during the year of 8,200 specimens and almost 2,000 species. The chief accessions are as follows:

By purchase.—160 specimens from Rev. John Davis, collected in South Carolina, and 400 specimens from A. A. Heller, collected in northern California and southern Oregon.

Through exchange.—290 specimens from Ira W. Clokey, Denver, Colorado, collected in Colorado, and 220 specimens of California mosses collected by Dr. M. A. Howe; also 300 duplicates from the Cosmopolitan Mitten Moss Herbarium, from the New York Botanical Garden.

Sixty-eight different correspondents sent in specimens chiefly for identification. The following are the most notable:

Mr. Ellsworth Bethel, Denver, Colorado, 281 from Denver and 21 from California and Nevada; Mrs. Mary Strong Clemens, 150 from Yosemite National Park and 401 from Plumas and Amador counties, California, and southern Oregon; J. August Kusche, 178 from Hawaiian Islands; Mrs. G. Earle Kelly, 65 from various parts of California; Mr. Vincent Jones, 72 from various parts of California; Mrs. Marian L. Campbell, 74 from various parts of California; Mrs. E. C. Sutliffe, 88 from various parts of California; Howard E. Phelps, 50 from Pullman, Washington; and Ira C. Otis, 74 from Cascade Mountains, Washington.

The California State Floral Society gave a collection, chiefly of exotic ferns, made by the late Mrs. L. A. Hodgkins. It consists of 76 large mounted sheets and 171 smaller specimens, besides a small collection of flowering plants collected by the late George W. Dunn.

Dr. G. Dallas Hanna, besides his own collection of 76 specimens from Unalaska, induced Miss Danforth and Miss Miller, two Unalaska teachers, to collect for the Academy, and they added 18 specimens. Mr. E. C.

Johnston also collected 130 specimens and many duplicates on St. George Island at Dr. Hanna's suggestion. Mr. Eric Walther, who has been indefatigable in seeking for the different species cultivated in Golden Gate Park so as to label them under my supervision, has added about 450 specimens, chiefly exotics, many of them new to the collection.

The curator spent a short time in April along the southern boundary of the state and collected 285 species and duplicates. During the visit in June to attend the meeting of the Pacific Division of the American Association for the Advancement of Science at Seattle, a small collection of about ninety species was made around Seattle, and on a short trip to Victoria and Nanaimo, British Columbia, 247 species and duplicates were collected. Exceptional opportunities for collecting were given by the members of the British Columbia Biological Station, who offered both hospitality and guidance. Several small collections were made in Solano, Marin and San Francisco counties, chiefly in type localities.

Much time has been spent in naming the trees and shrubs in Golden Gate Park so as to correctly label them. In order to facilitate this work, books not in the Academy library are greatly needed as the plants in the park come from all parts of the world. About 600 species have been named and labels attached to 2000 plants. Some of the genera, such as Acacia, Eucalyptus, Veronica, Escallonia, and the bamboos have been very difficult. Duplicate specimens are being collected and prepared to send to the best authorities for verification of the identifications.

The care of the growing herbarium takes much time, and a great deal of the detail work falls on the curator. This prevents the accomplishment of original work which should be done.

The flower show in the vestibule fills a great want in the community. During the year hundreds of species of exotic and native plants are exhibited labelled with scientific and common name and native home. Without the care and attention of Mrs. Johanna E. Wilkens it would be impossible to keep this clean and attractive.

The California Botanical Club has about 60 members and holds meetings once a week either at the Academy or on an excursion to some place near the city. Its members help the herbarium in many ways, particularly Mrs. Marian L. Campbell and Mrs. E. C. Sutliffe, who bring in specimens continually for the herbarium and the flower show. Mrs. Enid Reeves Michaels, one of the members now residing in the Yosemite Valley, has been keeping up a flower show in the valley throughout the season, at her own expense and by her own efforts. Recently, the Club has purchased for the Museum 360 pictures of California wild flowers photographed and colored with great skill and accuracy by Antone J. Soares. These will be installed soon so as to be on exhibition in the Museum.

Duplicates distributed.—230 to the Agricultural College, Buenos Aires, in exchange; 360 to the Royal Herbarium, Kew, for exchange; 205 to the Herbarium of the British Museum, for exchange; 300 to the Arnold Arboretum, for exchange.

All our Senecios have been sent to Dr. J. M. Greenman at the Missouri Botanical Garden, who is monographing the genus, and our undetermined

senting 744 named species, with portions of two families yet to be worked up. As one result of his systematic work on the Hemiptera the curator has prepared descriptions of 50 new species and one new genus which are awaiting more favorable conditions for publication. Academy material in the order Orthoptera, which includes the grasshoppers, crickets and their relatives, has been determined by Mr. Morgan Hebard of Philadelphia, who also has added many eastern forms to our collection. Unfortunately, the lack of cabinet boxes precludes the possibility of arranging these interesting insects this year. Large additions have been made to the collection of Coleoptera, or bettles, but the complete reärrangement of these insects has awaited the publication of the new Leng Catalogue of Coleoptera.

Accessions to the Academy's collection of insects during the year 1920 number 24,861 specimens to which must be added 3,146 specimens in the Stretch collection, transferred as a permanent loan or deposit from the University of California, making a total of 28,007 additions for the year. Of this number, 9,525 were received as gifts from friends of the Academy, 5,062 were obtained by purchase, 3,146 as a permanent loan and 10,274 were added through field work by the curator. The mounting and labelling of this mass of material has consumed much of the time of the curator, although he was fortunate in having the help of Miss Helen Sanford for four months and of Mr. J. O. Martin for one month. Some of the principal gifts to this department received during the year were: from Mr. W. M. Giffard of Honolulu, 485 aculeate Hymenoptera from the Sierras; from Mr. Morgan Hebard of Philadelphia, 378 Orthoptera; from Mr. L. R. Reynolds, 138 Hemiptera from Mexico; from Maj. Chapman Grant of Oklahoma City, 150 insects; from Mr. E. A. Dodge, 423 moths; from Mr. C. L. Fox, 991 insects, largely from Siskiyou County, California; from Dr. E. C. Van Dyke 1717, mostly from the state of Washington; from Mr. J. E. Law, 450 from Arizona; and from Dr. G. Dallas Hanna, 2441 specimens from the Pribilof Islands, taken by him last summer, and perhaps the largest collection of insects ever taken on these islands at one time. Other valuable material has been received from Dr. F. E. Blaisdell, Mr. J. R. Leach, Dr. J. A. Comstock, Mr. J. O. Martin, Mr. S. E. Cassino, Mrs. E. P. Van Duzee, Mrs. H. E. Ricksecker, Mr. L. S. Slevin, Mr. J. R. Slevin, Mr. F. X. Williams, Mr. C. Howard Curran, Dr. R. Ottolengui and Mr. B. G. Thompson.

The field work of the curator during 1920 consisted of a trip to Half Moon Bay, April 12 to 13; a trip by automobile to San Diego, April 19 to 28, as guest of Mr. W. M. Giffard; one to Bryson, Monterey County, May 16 to 23; one to Sacramento, June 2 to 3, as guest of Mr. Giffard; a trip to Seattle and Forks, Washington and Vancouver Island, B. C., June 14 to July 14, and one to Santa Cruz, November 3 to 4, as guest of Mr. E. A. Dodge. In addition several short Sunday trips to nearby points have been taken and many evenings have been spent collecting moths at light about store windows in the city; and, thanks to the kindness of Miss Alice Eastwood, the curator was able to make use of her cottage on the slopes of Mt. Tamalpais for night collecting of moths during the whole month of March.

This department has received assistance in the determination of material from a number of specialists besides those already mentioned and has rendered assistance to others, principally by the determination of Hemiptera. The curator, during the past year, as a part of the work of his department, has been in more or less regular correspondence with over 125 individuals, mostly workers in the science of entomology.

But one paper by the curator has been published during 1920. This was issued as Vol. 9, No. 13, of the Proceedings of the Academy and contains descriptions of 28 new species of North American Hemiptera. Several later papers await opportunity for publication.

It is expected that the energies and resources of this department for the coming year largely will be absorbed by the proposed Academy expedition to Lower California and in the preparation and study of the material taken.

E. P. VAN DUZEE, *Curator.*

DEPARTMENT OF HERPETOLOGY

The Department of Herpetology during the year 1920 progressed satisfactorily, and the work accomplished compares favorably with that of previous years.

At the beginning of the year 1920 the Academy's collection of reptiles and amphibians numbered 40,038 specimens. There have been added during the year 1,466 specimens, so that the collection has grown to more than 41,000 specimens.

The number of specimens added during each of the past six years has been about as follows:

1915	800	specimens
1916	1500	"
1917	1600	"
1918	1724	"
1919	2666	"
1920	1466	"

Gifts of specimens during the year have been received as follows:

From	Patrick H. McGee	3	specimens
"	Gme de la Motte	1	specimen
"	Mrs. J. E. Wilkins	2	specimens
"	Dr. Barton W. Evermann	1	specimen
"	H. H Hunt	1	"
"	Miss Marjorie D. Cole	1	"
"	H. G. Huges	1	"
"	Ralph Borden	1	"
"	Dr. E. C. Van Dyke	13	specimens
"	J. D. Flett	2	"
"	Fred Maag	1	specimen
"	J. R. Slonaker	2	specimens
"	John O. Snyder	209	"
"	F. X. Williams	30	"
		268	specimens

Two collecting trips were undertaken to:

1. Carmel, Monterey County, and Campo, San Diego County, California.
2. Arizona.

Specimens have been secured from 12 counties of California, as follows:

Contra Costa	1 specimen
Kern	1 "
Los Angeles	1 "
Madera	2 specimens
San Benito	1 specimen
San Diego	7 specimens
San Francisco	1 specimen
San Joaquin	1 "
San Luis Obispo	1 "
San Mateo	5 specimens
Santa Clara	1 specimen
Sonoma	1 "

Specimens from other localities are:

Arizona	890 specimens
Connecticut	2 "
Idaho	18 "
Utah	217 "
Washington	9 "
Wisconsin	2 "
Australia	28 "
Celebes, D. E. I.	1 specimen
Hawaiian Islands	205 specimens
Laysan Island	5 "
Lower California	1 specimen
New Zealand	18 specimens
Philippine Islands	1 specimen
Vancouver Island, British Columbia	6 specimens

The classification and arrangement of the collection was continued during part of the year.

Considerable research work has been accomplished during the year and a further study of the gopher-snakes west of the Rocky Mountains has been published.

The snakes of the genus *Lampropeltis* were borrowed for study by Dr. Blanchard, and the lizards of the genus *Gerrhonotus* were studied by Mr. Ivan Johnston. Other students also made use of the collection.

During the year the Assistant Curator, Mr. J. R. Slevin, carried on explorations in California and Arizona, where he spent the months of May, June, July, August, and part of September, and secured large collections.

JOHN VAN DENBURGH, *Curator.*

Tertiary fossils to be used in connection with his studies of coastal plains geology. Others who have borrowed certain specified groups in past years, but who have not completed their studies at this date, are: Dr. Earl L. Packard, University of Oregon, Cretaceous fossils; Dr. S. S. Berry, Redlands, California, Chitons; and Dr. W. S. W. Kew, fossil sea urchins.

Faithful and very valuable assistance has been rendered in the Department by Messrs. Merle Israelsky and Georges Vorbe, students of the University of California, and by Mr. William Barbat of St. Mary's College.

G. Dallas Hanna, *Curator.*

Department of Invertebrate Zoology

The collections have been increased by specimens collected by the Curator and Mr. W. S. Wallace of Monterey Bay. Mr. Wallace has specialized on hydroids and is naming the material as rapidly as acquired.

A trip to Vancouver Island which the Curator had intended to make in October had to be postponed until April on account of unfavorable tides and the closing of the Nanaimo Biological Station, which was to be used as a base of operations. The primary object of the trip was to study in life the shore and shallow-water sea stars, of which a considerable number of nominal forms have been described from that general region.

Dr. G. Dallas Hanna made a collection of sea stars, with extensive color notes, at St. Paul Island, Bering Sea, and at Unalaska, during the summer.

Dr. Gertrude Van Wagenen, who is studying at the Hopkins Marine Station, the corals and actinians of Monterey Bay, will contribute a set of named specimens.

W. K. Fisher, *Curator.*

Librarian's Report

The growth of the library during the year 1920 was greater than during the preceding year, accessions having increased by purchase, by exchange and by gift. The low rate of foreign exchange made it seem advisable to place larger orders with European dealers and by this means many valuable sets were received at a very reasonable figure. Recovery from the European War has made possible the resumption of exchanges with many foreign societies, and lastly, more than the usual number of gifts have been received from friends of the Academy. Accessions to the library for the year number 1370 bound volumes, of which 526 were received by gift, 544 by purchase and 300 through exchange with other institutions. In addition to the bound volumes a large number of pamphlets and parts of volumes were received. By far the larger part of the books and pamphlets presented to the Academy library were from the Adolph Sutro library, received through the generosity of Doctors Geo. W. and Emma Sutro Merritt. This material from the Sutro library includes 402 bound volumes and 4248 miscellaneous numbers of government bulletins and reports and similar unbound material, besides a large number of separate papers, many of which will be useful later in completing sets. During the year 2200 volumes were accessioned, making the total number of volumes accessioned on December 31, 1920, 14,080.

Two new metal book stacks were erected in the basement library room, furnishing shelving space for 2400 volumes. This additional shelving has made it possible to relieve and rearrange some overcrowded subjects, thus adding materially to the orderly arrangement of the books stored in the basement room.

Work in the library department has, as in the two previous years, been in the hands of Miss McClellan and Mrs. Van Duzee, and to the faithful and efficient performance of the duties devolving upon these two is due the progress made in this department of the Academy's activities.

The collating, classification and cataloging has been completed in the series of publications of scientific societies and institutions issued in foreign languages, and in the subjects of engineering, chemistry, geography, mathematics, medicine, mining, ethnology and archæology and work on several other subjects is nearing completion. All current accessions also have been cataloged and placed on the shelves promptly as received. Use of the library by the Academy membership has shown a gratifying increase and it is hoped that with the improvement of the catalogue and the more systematic arrangement of the books on the shelves will come an increasing and more effective use of the books we have, both by the museum staff and the Academy membership in general.

E. P. VAN DUZEE, *Assistant Librarian.*

DEPARTMENT OF MAMMALOGY

As heretofore, this department has been coòrdinated with that of Ornithology, and what field work was accomplished was done incidentally with that in the latter department.

A succession of dry seasons in northern California made the collecting of small rodents a difficult matter on account of their scarcity, but a considerable number was obtained.

The Academy's collection of mammals had never been completely checked up, labelled, or entered upon the accession register, but this work is now nearly finished. Many of the large skins were only salted or dried, but the necessity for the better preservation of these very valuable specimens became so evident that Mr. H. W. Vogelsang was employed to tan them. The larger proportion of these have been so treated with most satisfactory results.

These skins have heretofore been stored in the ordinary metal cases in use for the smaller mammals, and therefore not readily accessible. It was decided to build a hide room in which to hang them when tanned. For this purpose a space has been enclosed in the vacant store room at the northwest corner of the Mammal Hall, in which all hides will be easily accessible for examination.

Gifts to the department have been made by Messrs. F. S. Townsley, J. R. Slevin, Chas. Budd, Geo. A. Bailey, W. C. Hackmeier, Dr. Saxton Pope, the Golden Gate Park authorities, and others, as shown in the List of Accessions.

JOSEPH MAILLIARD, *Curator.*

Department of Ornithology

Active work in this department has been carried on throughout the year. While most of this work has consisted in the classification, registration, and arrangement of specimens, several field trips were undertaken and some valuable contributions made to the knowledge of the distribution and migration of our birds. Two weeks in the early spring were spent in Monterey County, California, for the purpose of observing the unusual influx of Clarke's Nutcrackers reported from there, and for studying the juncos of that part of the state, and some valuable records were obtained. Another field trip was made in company with Dr. G. Dallas Hanna, of the Department of Paleontology, to whose valuable assistance this department is greatly indebted, into the region near "The Pinnacles," San Benito County, California, and to Pacheco and Panoche passes in order to note migrations. Interesting data were secured on this trip in connection with the spring migration of certain species and many specimens of birds and eggs were brought back.

The principal field trip of the year was to Siskiyou County, California, made in company with Mr. F. G. Gilchrist and Mr. Frank C. Holman, as assistants. Five weeks were passed in the field, the greater portion in camp at various spots. Although the very dry season had an unfortunate influence upon the bird life of the localities visited, the expedition gathered a number of specimens from a but little investigated part of the state, better defined the known habitats of several species of birds, and obtained some good records. The regions visited were localities west and north of the base of Mt. Shasta; Forest House Mountain, west of Yreka; and the Salmon Mountains, west of Greenview. Thanks are especially due to Mr. F. C. Holman, in the capacity of volunteer assistant, for his efforts to make the expedition a success.

Another field trip was made, in company with Mr. Chase Littlejohn, present assistant in this department, to the Mt. St. Helena range in Lake County, California, further to study the fall migration of fox sparrows. Fifteen days were spent in this work, and some very interesting observations were made, and numerous specimens secured.

The Curatorial work of the department has been principally that of cataloging and arranging specimens and bringing the card index up to date. The large increase in the number of specimens has necessitated the addition of fifteen metal cases for their installation, but, unless the near future brings unexpected fortune in the way of large donations, there should now be case room for the coming year, especially as a few cases will be freed from the mammalogical room.

The illness of Mr. Wm. Heim, who was mounting birds for the seasonal groups of the birds of Golden Gate Park, has delayed that work so that it is not yet systematically arranged, but a number of the birds of the park are in the cases, properly labelled, so that the public may profit thereby. Mr. Littlejohn has more specimens under way, and it is hoped to have these groups in fairly good shape within the next few weeks.

The principal donation to the department during the past year has been that of the W. Otto Emerson collection of study skins, consisting of some

5300 specimens, the life work of Mr. Emerson. This collection was purchased and donated to the Academy by Messrs. W. H. Crocker and John W. Mailliard. In this collection are many rare records for California, and, with the Mailliard collection, the Academy's representation of the land birds of this state is now placed on a good working basis for the use of all who may be interested in the study of ornithology.

Accessions to the Department of Ornithology proper are as follows:

Gifts:		
W. H. Crocker and J. W. Mailliard (Emerson collection)	5300	specimens
J. W. Mailliard	22	"
James Moffitt	5	"
G. Dallas Hanna	106	"
F. C. Holman	9	"
E. F. Eastman	1	"
J. D. Baker	2	"
C. A. Allen	2	"
W. E. Scott	3	"
Golden Gate Park	3	"
J. D. Hubbard	2	"
Wm. Lewis	1	"
Ralph Borden	7	"
J. A. Kusche	13	"
Dudley de Groot	3	"
Mrs. Stanley	2	"
J. R. Slonaker	190	"
Dr. W. Winterberg	1	"
Mrs. Rhodes	3	"
Chas. Townsley	2	"
J. G. Grundel	1	"
Exploration, etc.	849	"
Total accessions during the year 1920	6537	"
Total number of specimens in the Academy collections	38065	"

While this department was somewhat short-handed during the year, a great deal of work has been accomplished in the matter of rearranging the collection of birds for the reception of the large additions; and the installment of the oölogical collection is proceeding with reasonable speed.

JOSEPH MAILLIARD, *Curator.*

APPENDIX TO DIRECTOR'S REPORT

ACCESSIONS TO THE MUSEUM AND LIBRARY, 1920

Geological Survey of South Australia, Adelaide, Australia: Nine maps. Gift.

Allen, Mr. Lewis, Golden Gate Park, San Francisco: Twenty-three photographs of trees and shrubs and eight plants from Fresno. Gift.

Ashly, Mrs. A. H., Stockton: One botanical specimen from Morada. Gift.

Augsbury, Mrs. John C., San Francisco: Seven botanical specimens from Bartlett Springs. Gift.

Bailey, Mr. George A., Golden Gate Park, San Francisco: One black gopher. Gift.

Barbat, Mr. William F., San Francisco: Fossil shell conglomerate from Chase Camp, Mill Creek, Tehama County, probably Monterey Miocene in age. Gift.

Bassinger, Mr. A. J., Agricultural College, Davis: Nine plants from California. Gift.

Beck, Mr. Donovan Wayne, Burlington, Indiana: A collection of 15 bird eggs from Burlington, Indiana. Gift.

Becker, Mr. J. O., Keeper, Año Nuevo Light, California: Two whale bones from Año Nuevo Island and three Indian spearheads from shore opposite Año Nuevo Island, San Mateo County. Gift.

Bergman, Mr. Charles, San Francisco: Two botanical specimens from Ingleside for identification and one aquarium plant. Gift.

Berry, Dr. S. Stillman, Redlands: Three paratypes of three new subspecies of land mollusks described recently in the Proceedings of the California Academy of Sciences, five land shells from southern California, and three land mollusks from Canada. Gift.

Bethel, Mr. Ellsworth, Denver, Colorado: Fifteen specimens of Ribes from southern California, four botanical specimens from Nevada, 19 from California and 281 from Colorado. Gift.

Blaisdell, Dr. F. E., San Francisco: Seventy beetles from various localities and three books (The International Scientist's Directory, Check List of North American Birds—E. Coues, and Pacific Railroad Report, Vol. IX). Gift.

Blazic, Mr. Antone, Los Angeles: Twelve botanical specimens from Chico and Santa Barbara. Gift.

Borden, Mr. Ralph, Alameda: Seven Australian parrots in flesh. Gift.

Boston Society of Natural History, Boston, Massachusetts: Memoirs, three volumes; Occasional Papers, six volumes; Proceedings, 19 volumes. Gift.

Brimley, Mr. C. S., Raleigh, North Carolina: Fifty-one salamanders, 10 frogs, eight snakes, and two lizards. Purchase.

Brooks, Mr. Ben., Chicago, Illinois: Nine botanical specimens from Gary, Indiana. Gift.

Bud, Mr. Charles, Golden Gate Park, San Francisco: One porcupine. Gift.

Button, Mr. Fred L., Oakland: Four publications. Gift.

Cain, Mr. B. C., Salt Lake City, Utah: Twenty-one snakes, 157 lizards, 23 frogs, and 16 toads from Utah; two frogs, one toad, five salamanders and ten snakes from Idaho. Purchase.

California Botanical Club, San Francisco: One book. Gift.

California State Floral Society, San Francisco: Sixty-two large sheets of mounted ferns, chiefly exotics and named, also 14 unnamed, 171 smaller specimens unmounted of both exotics and native ferns, and

also 30 specimens of flowering plants collected by the late George W. Dunn. Gift.

Gray Herbarium, Harvard University, Cambridge, Massachusetts: One book (Florula Bostoniensis.—Joseph Bigelow). Gift.

Campbell, Mrs. Marian L., Mill Valley: Eight botanical specimens from Mill Valley and Los Altos, 40 from Lake Tahoe region and Sacramento, 18 from Solano County, and eight from Monte Rio. Gift.

Cappleman, Mrs. O. C., Mill Valley: One botanical specimen from Washington. Gift.

Cassino, Mr. S. E., Salem, Massachusetts: The Lepidopterist, Vols. II and III, Nos. 1-5. Gift.

Chilton, Dr. Charles, Canterbury College, Christchurch, New Zealand: Thirty-three specimens of land and freshwater shells from the Hawaiian Islands. Gift.

Clemens, Mrs. Joseph, Pacific Grove: One hundred and fifty specimens of plants from Yosemite National Park, 21 from Plumas, Shasta and Tehama counties, and 27 from other Pacific Coast localities. Gift.

Clokey, Mr. Ira W., Denver, Colorado: Two hundred and ninety specimens of Colorado plants. Exchange.

Cole, Miss Marjorie, Los Angeles: One botanical specimen. Gift.

Coleman, Mr. R. A., San Francisco: Thirty specimens of marine mollusks from California, including a beautiful series of *Brachydontes demissus*, a mussel introduced from the East coast of the United States with the Oyster and now well established on the eastern side of San Francisco Bay. Gift.

Crocker, Mr. Wm. H., and Mailliard, Mr. John W., San Francisco: The W. Otto Emerson collection of 5300 bird skins. Gift.

Crocker, Mrs. William H., Burlingame: One bulla from Umma (Toklia) in South Babylonia. Gift.

Crook, Dr. A. R., State Museum of Illinois, Springfield, Illinois: One book (Guide to the Mineral Collections in the Illinois State Museum.—Crook). Gift.

Crowell, Mr. A. Russell, Mexico: Nineteen recent shells from Mazatlan Bay. Gift.

Curran, Mr. C. Howard, Vineland Station, Ontario: Twenty specimens of Syrphidæ, including the types of 17 of his recently described species. Gift.

Danford and Miller, Misses, Unalaska: Eighteen botanical specimens from Unalaska. Gift.

Danmar, Mr. William, 5 McAuley Ave., Jamaica, New York: One book (Modern Nervanaism.—William Danmar). Gift.

David, Mr. Evan J.: One book (Leonard Wood on National Issues.—Evan J. David). Gift.

Davis, Rev. John, Hannibal, Missouri: One hundred and sixty botanical specimens from South Carolina. Purchase.

Day, Mr. Charles E., Parker, Arizona: Two specimens of copper ore and two of cactus from Parker, Arizona. Gift.

Dean, Mr. W. E., San Francisco: Sundry Academy publications. Gift.

de la Motte, Mr. G. W., San Francisco: One Gila monster from near Roosevelt Dam, Arizona. Gift.

Dickerson, Dr. Roy E., Manila, P. I.: Fifty-eight specimens of fossils and 16 freshwater shells from the Philippine Islands. Gift.

Dodge, Mr. E. A., Santa Cruz: One hundred specimens of lepidopterous insects, all mounted and determined. Gift.

Donohoe, Mrs. J. A., Menlo Park: Three botanical specimens from Menlo Park. Gift.

Doubleday, Page and Company, Garden City, New York: One book (The Life of Leonard Wood.—John G. Holme). Gift.

Eastwood, Miss Alice, California Academy of Sciences: One hundred and thirty-one botanical specimens from state of Washington; 280 specimens from British Columbia; 67 from northern California; 239 from southern California; and 56 miscellaneous specimens. Exploration.

Edwards, Mr. George W., San Francisco: Eight volumes (Battles and Leaders of the Civil War, Vols. 1-8). Gift.

University of Oregon, Eugene, Oregon: Six fossil land shells from Oregon. Gift.

Evermann, Dr. Barton Warren, California Academy of Sciences: One specimen Chert from Año Nuevo Island; a series of lavas from Kilauea Volcano; 39 land shells from lava rocks not far from Kukuku, Hawaii; 101 marine shells and coral from Honaunau, Hawaii; 18 specimens marine mollusks from Año Nuevo Island; and a collection of 15 eggs and nests of California birds. Exploration. Seven trays of buttons showing the various processes in the manufacture of these articles from freshwater mussels; 14 shells of freshwater mussels from which buttons are made; 1 tray of waste from button factory after being ground for poultry food; eight natural pearls from freshwater mussels; Koninklijk Magnetisch en Meteorologisch Observatorium te Batavia, Verhandelingen, No. 5; 67 publications of the Academy; one botanical specimen from San Francisco, one from Hawaii, and one from Alaska collected in July, 1892. Gift.

Faix, Mr. C. A., San Francisco: Two botanical specimens from San Francisco. Gift.

Falkenau, Prof. Louis, Alameda: Sundry Academy publications. Gift.

Flett, Prof. J. B.: One snake and one salamander from Washington State. Gift.

Fox, Miss Anna P.: Seventeen botanical specimens from Inyo County. Gift.

Fox, Mr. C. L., San Francisco: One hundred and four insects taken at Mount Rainier in July, 1919, and 887 insects from Siskiyou County. Gift.

Friends of Irish Freedom, Washington, D. C.: One book. Gift.

Gauthier-Villars et Cie., 55 Quai des Grands-Augustins, Paris, France: Eight books and pamphlets. Gift.

Giffard, Mr. W. M., Honolulu, T. H.: Four hundred and eighty-five Aculeate Hymenoptera from the Sierras. Gift.

Ghirardelli, Mrs. Domingo, San Francisco: Seed pods of various trees from Panama and two botanical specimens form Portland, Oregon. Gift.

Gilbert, Mr. Arch M., Mill Valley: One botanical specimen from Sebastopol. Gift.

Goodman, Dr. E., San Francisco: Three botanical specimens from San Francisco; 10 from Redwood Cañon and Piedmont and two from Mount St. Helena; two pieces of wood from the Petrified Forest and nine postal cards showing views of the Petrified Forest; and two other botanical specimens. Gift.

Grant, Miss Adele L., Missouri Botanical Garden: Ten botanical specimens from Fresno. Gift.

Grant, Major Chapman, Schofield Barracks, Honolulu, T. H.: One hundred and fifty insects from Oklahoma City. Gift.

Grundel, Mr. J. G., Oakdale: One albino western robin in the flesh. Gift.

Hackmeier, Mr. W. C., San Francisco: Two wild cats from Lassen County. Gift.

Hahn, Mrs., San Francisco: One botanical specimen from Kings County. Gift.

Hall, Dr. H. M., Berkeley: Twenty-seven unmounted and six mounted botanical specimens. Gift.

Hallawell Seed Co., San Francisco: One botanical specimen from Dixon. Gift.

Hanna, Dr. G. Dallas, California Academy of Sciences: Thirty-one marine mollusks from Moss Beach, California; 60 freshwater clams from Alaska; 15 freshwater clams from Washington; 3035 marine mollusks from Alaska and Bering Sea; 59 land and freshwater shells from the Bay Region of California and 2558 land and freshwater mollusks from San Benito County; 65 specimens of mollusks from Laguna Salada; 2441 insects from Pribilof Islands; 30 botanical specimens from Unalaska and 46 specimens from St. Paul Island; 130 plants collected by E. C. Johnston, from St. George Island, Alaska; one snake and one salamander from Contra Costa County; one snake from San Benito County; 10 skulls of Blue Foxes, three skulls of Steller's Sea Lion, 27 skulls of Fur Seals, two skulls and one skin of Hair Seal, and one skull of Reindeer, from St. Paul Island; two skulls of Polar Bears and one humerus of Polar Bear, from St. Matthew Island, Alaska; one skull of Kodiak Bear from Kodiak, and a few bones of Hair Seals from Alaska; 110 bird skins, 16 specimens of birds in formalin and 374 eggs from Alaska. Exploration. Sundry books and pamphlets. Gift.

Hawver, Mrs. Elizabeth Parsons, Bolinas: Eight botanical specimens from Mount Hood region. Gift.

Heath, Dr. Harold, Stanford University: One set (6 perfect eggs) of the Alaska Wren from St. George Island, Alaska. Gift.

Heller, Mr. A. A., Chico: Four hundred botanical specimens from northern California and southern Oregon. Purchase.

Herrin, Mr. William F., San Francisco: Seventeen botanical specimens from Shasta County and three specimens from Napa County. Gift.

Hicken, Dr. Cristobal M., Buenos Aires, Argentina: Twenty miscellaneous separates by C. M. Hicken and one copy Apuntes Historia Natural, Vol. II. Gift.

Hickman, Mr. J. B., Aromas: Two botanical specimens. Gift.

Hildebrand, Mr. Samuel F., Key West, Florida: Nine snakes, four lizards, five frogs, one toad, and two turtles. Gift.

Holladay, Mrs. E. B., San Francisco: Sundry papers and documents relating to the early history of the Academy; 13 books and pamphlets; a number of the early publications of the Academy. Gift.

Holman, Mr. F. C., San Francisco: Eight bird skins. Gift.

Howell, Mr. A. B., Pasadena: Eighteen mollusks from northwestern California. Gift.

Hubbard, Mr. J. D., Chico: One Red-tailed Hawk in flesh. Gift.

Israelsky, Mr. Merle C., San Francisco: Six oligocene fossils from San Lorenzo and 18 miocene fossils from vicinity of Walnut Creek. Gift.

Jackson, Mrs. Bell R., San Rafael: Ten botanical specimens from Marin County. Gift.

Jones, Mr. Vincent, San Francisco: Forty botanical specimens from Cedar Glen, Sierra County, and 32 from Vallejo, Suisun and Orwood. Gift.

Jordan, Dr. David Starr, Stanford University: Thirty specimens of fossil fishes from the Diatomaceous deposits at Lompoc, and one from the Derby Dam, Truckee River, Nevada. Gift.

Kelly, Mrs. G. Earle, Alameda: Forty-seven botanical specimens from Butte County; 17 from Plumas County, three from Monterey, and one from Alvarado. Gift.

Kusche, Mr. J. August, San Francisco: One hundred and seventy-eight specimens of Hawaiian plants; 150 insects from Hawaiian Islands, mostly moths, and 67 moths taken at Burlingame. Gift.

Law, Mr. J. Eugene, Museum of Vertebrate Zoology, Berkeley: Four hundred and fifty insects from southern California and Arizona. Gift.

Leavy, Mr. Aiken, Golden Gate Park, San Francisco: Five botanical specimens from Niles Nursery. Gift.

Lehrkind, Mr. O. F., San Francisco: Indian relics from Salt Lake District. Gift.

Le Masters, Mr. C., Bisbee, Arizona: One specimen bog-iron covered by malachite stains, and mineralogical specimens 75 per cent. copper from Sacramento Hill, Bisbee, Arizona. Gift.

Lewis, Mr. William C., Sausalito: One Great Blue Heron. Gift.

Maag, Mr. Fred, San Francisco: One lizard from Kern County. Gift.

Mailliard, Mr. John W. and Crocker, Mr. William H., San Francisco: The W. Otto Emerson collection of 5300 bird skins. Gift.

Mailliard, Mr. John W., San Francisco: Twenty-two miscellaneous pamphlets. Gift.

Mailliard, Mr. Joseph; Gilchrist, Mr. Francis; and Holman, Mr. F. C., California Academy of Sciences; Eighty-seven skins of small mammals, and 598 study skins of birds from California. Exploration.

Mailliard, Mr. Joseph, California Academy of Sciences: Six hundred and ninety-nine freshwater shells from Sonoma and Siskiyou counties. Exploration.

Biological Society of Washington, Proceedings, Vol. XXXII, pp. 207-234, 239-270, two pamphlets. Gift.

Martin, Mr. J. O., Berkeley: Five hundred and eleven beetles. Gift.

Masters, Mrs. Cornelia S., Pasadena: One botanical specimen from Yellowstone Park. Gift.

McAllister, Mr. M. Hall, San Francisco: Framed photograph of charter members of the Cordelia Shooting Club, organized July, 1880. Gift.

McLaren, Mr. John, Park Lodge, San Francisco: Five botanical specimens from Humboldt County; one deer and one bear in flesh. Gift.

McLellan, Miss Mary E., Berkeley: Three hundred and seventeen marine mollusks from Monterey Bay, and 13 miscellaneous volumes. Gift.

Meiere, Mrs. Ernest, Los Altos: Three botanical specimens from Los Altos, and four Japanese prints of flowers. Gift.

Meierdierks, Miss Marie, Alameda: Forty specimens of Swiss Alpine plants. Gift.

Department of Mines, Melbourne, Victoria, Australia: Two maps. Gift.

Menzies, Mr. Robert, San Rafael: Four botanical specimens from San Rafael. Gift.

Michaels, Mrs. Charles E., Yosemite: Five botanical specimens from Yosemite, and one from Mount St. Helena. Gift.

Miller, Mrs. C. E., Berkeley: Four botanical specimens from Santa Cruz and Catalina islands. Gift.

Miller, Mr. Irving, San Francisco: Nineteen botanical specimens from Pilot Knob, Inyo County. Gift.

Mouzin, Mr. Nicholas, Golden Gate Park, San Francisco: Four botanical specimens from Tuolumne Meadows and Golden Gate Park. Gift.

Moxley, Mr. George L., Los Angeles: One botanical specimen from the Sierra Nevada. Gift.

Newell, Mrs. Gwendolyn, San Francisco: Sundry Academy publications. Gift.

New Church Press, New York: Three books. Gift.

New York Botanical Garden, New York: Three hundred and ninety-five specimens of mosses, duplicates of the Mitten collection from various places; and 220 specimens of California mosses, collected by Dr. M. A. Howe. Exchange.

Nylander, Mr. Olof O., Caribou, Maine: Four pamphlets. Gift.

O'Keefe, Mr. T. C., Golden Gate Park, San Francisco: A set of three eggs of the Nuttall Sparrow, from deserted nest in Golden Gate Park. Gift.

Osterhout, Mr. George E., New Windsor, Colorado: Five botanical specimens from Colorado. Gift.

Otis, Mr. J. C., Seattle, Washington: Seventy-four botanical specimens from Chelan and King counties, Washington. Gift.

Paige, Mrs. George, San Francisco: Forty-one volumes. Gift.

Pechart, Miss Ruth, Boulder Creek: One botanical specimen from Boulder Creek. Gift.

Peers, Miss Susie, San Francisco: Sundry volumes. Gift.

Perkins, Miss Janet, San Francisco: Thirteen botanical specimens from California. Gift.

Geological Survey of Western Australia, Perth, Australia: Fourteen maps. Gift.

Phelps, Mr. Howard E., Pullman, Washington: Fifty botanical specimens from Pullman. Gift.

Phelps, Mrs. Kate E., San Francisco: Twenty plants from Leavenworth, Washington. Gift.

Pope, Dr. Saxton, Butler Building, San Francisco: Four grizzly bear skins and skeletons from the Yellowstone Park. Gift.

Porter, Dr. Charles B., San Francisco: One Japanese sword. Gift.

Probert, Mrs., San Francisco: Five books and one pamphlet. Gift.

Putnam's, G. P. Sons, New York: Six books. Gift.

Putnam, Mrs. Osgood, San Francisco: Sundry Academy publications. Gift.

Raspail, Mr. Xavier, Gouvieux, France: One book (Trente ans de critiques medicales et scientifiques.—Raspail et Pasteur). Gift.

Reed, Mrs. C. A., Santa Cruz: Fourteen botanical specimens from Santa Cruz. Gift.

Reynolds, Mr. L. R., Watertown, Massachusetts: One hundred and thirty-eight Hemiptera from Orizaba, Mexico. Gift.

Rhodes, Mrs. M. B., Monterey: Three Western Evening Grosbeaks in flesh. Gift.

Rixford, Mr. G. P., San Francisco: Four botanical specimens. Gift.

Ruble, Mr. Russell, Geddes, South Dakota: A collection of nine bird eggs from Geddes, South Dakota. Gift.

Ruddock, Mr. George T., Bakersfield: One botanical specimen from Bakersfield. Gift.

Sayler, Mr. F. L., Berkeley: One hummingbird's nest. Gift.

Schieffelin, Miss Rose G., Medford, Oregon: One botanical specimen from Medford. Gift.

Seale, Mr. Alvin, Santa Cruz: Seven specimens of the Philippine window-shell, *Placuna plicenta,* from Manila Bay, P. I. Gift.

Sessions, Miss Kate O., San Diego: Three botanical specimens from San Diego. Gift.

Slevin, Mr. Joseph R., California Academy of Sciences: Thirty-one salamanders, one snake and two lizards; five salamanders from San Mateo County; 14 bats from Santiago, Lower California; 125 specimens of land mollusks from Arizona; one land shell from Lower California; a collection of eight bird eggs from Arizona. Exploration. Six photographs of desert plants. Gift.

Small, Mr. E. C., Berkeley: One specimen of Vanadium ore from Arizona. Gift.

Smith, Miss Emily, San Francisco: Two botanical specimens from Collinsville. Gift.

Smith, Mr. L. E., Sisson: One botanical specimen from Siskiyou County; Flora of California, Parts 1-2 by W. I. Jepson. Gift.

Stanford University, through Dr. David Starr Jordan: Five slabs of fossil fishes from Lompoc. Gift.

Stanley, Mrs., Colusa: Two skins of Terns; and 20 botanical specimens from Korea. Gift.

Stoney, Miss Kate D., San Francisco: Two botanical specimens from San Luis Obispo and one from the Grand Cañon. Gift.

Sutliffe, Mrs. E. C., San Francisco: One hundred and eighty-four specimens of cultivated and native plants of California. Gift.

Geological Survey of New South Wales, Sidney, Australia: Two maps. Gift.

Tableman, Mr. Fred, Newark, New Jersey: Two mounted radulæ of mollusks. Exchange.

Thompson, Mr. David G., United States Geological Survey, Washington, D. C.: Seven botanical specimens from California. Gift.

Townsley, Mr. F. S., Yosemite: One flying squirrel and two cardinals. Gift.

Turner, Miss Laura A. L., Pasadena: One botanical specimen from Pasadena. Gift.

Van Denburgh, Dr. John, California Academy of Sciences: One lizard from Pekin, China. Gift.

Van Duzee, Mr. E. P., California Academy of Sciences: Seven hundred moths from Mount Tamalpais; 1298 insects from San Diego; 370 insects from Sacramento; 2672 insects from Monterey County; 411 insects from Marin County; 3823 insects taken in western Washington and on Vancouver Island during June and July. Exploration. One book. Gift.

Van Duzee, Mr. E. P. and Mrs. Helen, California Academy of Sciences: Three hundred and eighteen insects from Half Moon Bay, San Mateo County. Exploration.

Van Duzee, Mrs. Helen, California Academy of Sciences: Three hundred and eighty-three insects from western Washington and Vancouver Island. Gift.

Van Dyke, Dr. E. C., University of California, Berkeley: Fifteen hundred and seventy-three insects from Vancouver Island and Washington, largely from Mount Rainier; 117 land shells from various parts of the United States and Canada; four salamanders and three frogs from Washington; six salamanders from Vancouver Island; and one land shell from Seattle. Gift.

Walther, Mr. Eric, Golden Gate Park, San Francisco: Eight hundred and twenty-four cultivated and native plants of California. Gift.

Walter, Mr. Frank, Los Angeles: Two botanical specimens from San Diego, one from Mount Wilson, 10 from Santa Barbara, and two from Los Angeles. Gift.

Walter, Miss Henrietta, San Diego: One botanical specimen from San Diego. Gift.

Carnegie Institution of Washington, Washington, D. C.: Publications Nos. 272, 282, 297, and 298. Gift.

United States Department of Agriculture, Washington, D. C.: Two volumes of Academy's proceedings. Gift.

United States Coast and Geodetic Survey, Washington, D. C.: Twenty-five maps. Gift.

United States Department of Agriculture, Washington, D. C.: Four maps. Gift.

Weeks, Dr. Alanson, San Francisco (through Mr. John C. Augsbury, San Francisco): Forty-four specimens of Eskimo workmanship, collected in Bering Sea about 1898-1900. Gift.

West, Mr. Harry P., San Francisco: Seven botanical specimens from Plumas County. Gift.

Westdahl, Mrs. F., San Francisco: Thirty-five specimens of ornamental shells. Gift.

Wible, Mr. Curtis, Bakersfield: One botanical specimen from Bakersfield. Gift.

Wilkens, Mrs. Johanna E., San Francisco: One botanical specimen from Golden Gate Park. Gift.

Williams, Mr. F. X., Honolulu, T. H.: Ten adults and 2 pupæ of *Cellerio callida* from Hawaiian Islands, mounted and determined; 20 specimens of butterflies and moths from Arizona; 17 frogs, and 11 lizards from North Queensland, Australia; one lizard from Hawaiian Islands; and one snake from Philippine Islands. Gift.

Wilson, Mrs. Arnott, Atlas: Three botanical specimens. Gift.

Wilson, Mr. Charles J., London, England: Eighty-one study skins of birds from Malay States. Gift.

Winterberg, Dr. Wolrad, San Francisco: One male Lewis Woodpecker. Gift.

Wollenburg, Mr., San Francisco: One albino gopher in flesh. Gift.

Wright, Miss Alice B., San Francisco: One specimen of *Pinus monophylla* from Nevada. Gift.

Wright, Mrs. E., Calistoga: Two botanical specimens. Gift.

REPORT OF THE TREASURER—*Continued*

Receipts		
Brought forward		$129,752.27
Expenditures		
Expense	$ 2,730.07	
General Salary Expense	17,237.42	
Legal Expenses	149.90	
Bills Payable	10,000.00	
Insurance	1,821.63	
Interest	15,886.11	
Museum, Department Appropriations	8,637.83	
Museum, Department Appropriations, Salaries	11,367.52	
Library	2,026.37	
Publication	4,067.94	
Office Furniture	9.36	
Tools and Equipment	57.25	
Ignatz Steinhart Trust Interest	119.96	
Steinhart Aquarium Preliminary Expense	2,190.85	
U. S. Treasury Certificates, Ignatz Steinhart Trust	19,000.00	
U. S. Treasury Certificates	27,000.00	
Post Card Sales	424.60	
Roosevelt Elk Group	10.75	
Grizzly Bear Group	24.92	
Sundry Creditors	2,088.37	
Sundry Advances (Museum)	5,529.73	
Yosemite Game Paddocks	1,840.50	
Contingent Fund	287.81	
		$132,508.89
March 31, 1921, Balance due Crocker National Bank		$ 2,756.62

RUDOLPH J. TAUSSIG,
By C. E. GRUNSKY, *Treasurer*

Examined and found correct.

McLAREN, GOODE & Co., *Certified Public Accountants.*

San Francisco, Cal., April 18, 1921.

INCOME AND OPERATING EXPENSES

For the Period April 1, 1920, to March 31, 1921

Income:		
Charles Crocker Scientific Fund Endowment Income		$ 1,318.84
James Lick Endowment Income		53,076.83
General Income		16,172.03
Dues		3,655.00
Expenditures:		
General Expense	$ 2,869.05	
Salaries	28,797.53	
Legal Expenses	149.90	
Interest	14,869.90	
Insurance	1,821.63	
Balance to Surplus Account	25,714.69	
	$74,222.70	$74,222.70

SUMMARY OF SURPLUS ACCOUNT

March 31, 1921

Balance March 31, 1920		$335,115.60
Add Excess of Income over Operating Expenses.	$25,714.69	
Library Account, Purchases from W. G. Wright Fund in 1920-21	66.50	
John W. Hendrie Endowment Income	988.58	
Post Card Sales	1,229.28	
Albert Meyer Donation	150.00	
		28,149.05
		$363,264.65
Less Depreciation		14,885.88
		$348,378.77

IGNATZ STEINHART TRUST

March 31, 1921

Bequest from the Ignatz Steinhart Estate		$250,000.00
Interest on temporary investments		21,962.44
Balance Investments over Receipts		31.12
		$271,993.56
Investments:		
Steinhart Aquarium Preliminary Expense	$ 2,993.56	
Temporary Investments:		
Bills Receivable	250.000.00	
U. S. Treasury Certificates	19,000.00	
	$271,993.56	

BALANCE SHEET
March 31, 1921

Assets

Real Estate:		
Market Street Lot	$600,000.00	
Jessie Street Lot	8,083.65	
Commercial Building	516,818.66	
		$1,124,902.31
Stocks:		
60 Shares Savings Union Branch of the Mercantile Trust Co.		13,600.00
Ignatz Steinhart Trust:		
Bills Receivable	250,000.00	
U. S. Treasury Certificates	19,000.00	
Steinhart Aquarium Preliminary Investment	993.56	
Steinhart Aquarium Building Appropriation	2,000.00	
		271,993.56
U. S. Treasury Certificates		14,000.00
Museum Construction		191,690.92
Museum:		
General Collections	102,268.49	
Tools and Equipment	24,134.15	
		126,402.64
Library:		
Books and Equipment	20,848.16	
Publication	25,712.44	
		46,560.60
Office Furniture		3,338.69
Foreign Exchange		128.23
Sundry Advances:		
Gulf of California Expedition	4,988.07	
Prager Herbarium	156.03	
Yosemite Game Paddocks	335.50	
		5,479.60
Post Cards in Stock		3,266.96
		$1,801,363.51

BALANCE SHEET—*Continued*

Liabilities

James Lick Endowment	$804,902.31	
Charles Crocker Scientific Fund Endowment	20,000.00	
John W. Hendrie Endowment	13,600.00	
		$838,502.31
Ignatz Steinhart Trust	250,000.00	
Ignatz Steinhart Trust, Interest Account	21,962.44	
		$271,962.44
Alvord Bequest Botanical		5,000,00
A. K. Macomber Donation		3,500.00
William C. Van Antwerp Donation		5,120.00
William H. Crocker Donation		3,568.73
W. B. Bourn Donation		2,659.31
J. D. Grant Donation		2,710.42
Herbert Fleishhacker Donation		3,500.00
Ogden Mills Donation		5,000.00
John W. Mailliard Donation		1,250,00
S. Levi Donation		103.60
William M. Fitzhugh Donation		200.00
Bills Payable		290,000.00
Sundry Creditors		2,320.00
Cash:		
Overdraft with Crocker National Bank	2,756.62	
Less Cash in Safe	54.57	
		2,702.05
Depreciation		14,885.88
Surplus		348,378.77
		$1,801,363.51

W. W. SARGEANT,
Secretary, Board of Trustees.

We have examined the foregoing Balance Sheet, together with the books and accounts of the CALIFORNIA ACADEMY OF SCIENCES, and in our opinion it is properly drawn up so as to exhibit a true and correct view of the Academy's affairs, as shown by the books.

MCLAREN, GOODE & CO.,
Certified Public Accountants.

San Francisco, Cal.,
April 18, 1921.

INDEX TO VOLUME X, FOURTH SERIES

New names in **heavy-faced type**

COMMITTEE ON PUBLICATION

GEORGE C. EDWARDS, *Chairman*

C. E. GRUNSKY — BARTON WARREN EVERMANN, *Editor*

PROCEEDINGS

Fourth Series

VOLUME I

Expedition of the California Academy of Sciences to the Galapagos Islands, 1905-1906.

Pages 1-6. I. Preliminary Description of Four New Races of Gigantic Land Tortoises from the Galapagos Islands. By John Van Denburgh. (*Issued December 20, 1907*)	$0.25
Pages 7-288. II. A Botanical Survey of the Galapagos Islands. By Alban Stewart. Plates I-XIX. (*Issued January 20, 1911*)	1.75
Pages 289-322. III. The Butterflies and Hawk-Moths of the Galapagos Islands. By Francis X. Williams. Plates XX-XXI. (*Issued October 7, 1911*)	.50
Pages 323-374. IV. The snakes of the Galapagos Islands. By John Van Denburgh. Plates XXII-XXX. (*Issued January 17, 1912*)	.50
Pages 375-404. V. Notes on the Botany of Cocos Island. By Alban Stewart. Plates XXXI-XXXIV. (*Issued January 19, 1912*)	.35
Pages 405-430. VI. The Geckos of the Galapagos Archipelago. By John Van Denburgh. (*Issued April 16, 1912*)	.35
Pages 431-446. VII. Notes on the Lichens of the Galapagos Islands. By Alban Stewart. (*Issued December 17, 1912*)	.25

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